903R78001

EPA Report Number
November 1978

A PARTICULATE MATTER STUDY FOR THE METROPOLITAN BALTIMORE INTRASTATE AIR QUALITY CONTROL REGION

by

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Including Appendix E by
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under

EPA Contract Number 68-02-2850

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Philadelphia, Pannsylvania 19106

and

Project Officer, Alvin L. Bowles

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FOREWORD

Where violations of the national primary 24-hour standard for total suspended particulate (TSP) matter occur, it is necessary to identify the sources which contribute to these violations and to adopt appropriate source control strategies which will lead to the elimination of violations. Region III of the U.S. Environmental Protection Agency is actively engaged in helping states to identify the causes of TSP air quality violations by examination of material collected by high-volume filter samplers and by extending their emission inventories to include fugitive emissions. In this study GEOMET, Incorporated has compiled a fugitive emission inventory for the Metropolitan Baltimore Intrastate Air Quality Control Region (MBIAQCR) and has characterized the particulate matter captured by high-volume samplers at three sites in the MBIAQCR which had registered violations of Federal standards during 1976.

William E. Belanger
Project Officer
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ABSTRACT

Portions of the MBIAQCR exceeded the national primary 24-hour standard for TSP in 1975 and 1976 and are expected to continue to exceed this standard through 1985 unless mitigative action is taken. In response to this, hi-vol sampling was done at three representative locations within the nonattainment area.

According to results from microscopical analysis of the hi-vol filters, about 50 percent of the filter particulate was mineral. This result agreed with empirical emission equation calculations which indicated that the largest particulate emission rates were from active dirt and gravel roads, unpaved parking lots and active construction sites. By applying appropriate control strategies, the TSP emissions can be reduced by about 35 percent and thus result in attainment of both the 24-hour and annual TSP standards for most areas within the MBIAQCR.

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SECTION 1

INTRODUCTION

BACKGROUND

In the Metropolitan Baltimore Intrastate Air Quality Control Region (MBIAQCR) violations of both the annual and 24-hour standards for total suspended particulate matter have occurred and will continue to occur through 1985 at a number of locations in the region. The objective of this report is to identify those air pollution emission sources or classes of sources which are contributing to the exceedance of the National Ambient Air Quality Standards (NAAQS) for total suspended particulates (TSP) and the extent to which each source is a contributor. Of particular concern is the extent to which fugitive dust emissions contribute to this problem.

At the time that State Implementation Plans were first developed, no quantifiable estimates of the impact of fugitive emission sources were available. Therefore, most states did not adopt regulations to minimize emissions from such sources. However, it is now believed that fugitive emission sources may be major contributors to the particulate problem in Baltimore and in other cities. Fugitive emissions are of two types: (1) those that result from industrial operations and (2) those dusts that became airborne due to forces of wind, man's activity or both. In some industrial operations those particulates that escape through windows, doors or vents, but not through control devices, stacks or flues, are categorized as fugitive. Specific sources can be metallurgical furnace operations, materials handling, transfer and storage operations and crushing and grinding operations. Wind blown dust can result from paved and unpaved roads, wind erosion of exposed surfaces, construction sites, and uncovered aggregate storage piles.

Fugitive emissions can have a greater effect on ground-level air quality in the vicinity of a source than stack emissions. Stack emissions are released above ground level usually with upward velocity and buoyancy. Fugitive emissions occur near the ground and generally remain near ground level downwind.

Monitoring data for TSP have been archived by the Maryland Bureau of Air Quality and Noise Control (BAQNC) and show violations of both primary and secondary NAAQS occurring in the region. Table 1 lists the monitoring stations in the MBIAQCR at which the annual standards for TSP were exceeded in 1975 and 1976. Table 2 shows those stations at which the 24-hour standards were exceeded.

TABLE 1. STATIONS EXCEEDING ANNUAL TSP STANDARD*
IN THE METROPOLITAN BALTIMORE AQCR IN 1975 AND 1976

Station	1975 Annual Geometric Mean (μg/m^3)
Fire Dept. HQ	86
Fire Dept. #10	128
Ft. McHenry	86
Fire Dept. #22	86
Patapsco STP	150
S.E. Police Station	78
Station	**1976 Annual Geometric Mean (μg/m^3)**
Fire Dept. #10	164
Fire Dept. #22	82
Ft. McHenry	105
Patapsco STP	144
S.E. Police Station	77
AAI	90

* Annual Standard = 75 μg/m^3 geometric mean

TABLE 2. STATIONS EXCEEDING 24-HOUR TSP STANDARDS IN THE METROPOLITAN BALTIMORE AQCR IN 1975 AND 1976

Stations Exceeding Federal Primary Standard*	2nd Highest 24-Hour TSP Concentration ($\mu g/m^3$)	Year
Riviera Beach	357	1975
Fire Dept. #10	358	1975
Patapsco STP	398	1975
Fire Dept. # 10	559	1976
Patapsco STP	509	1976
Lansdowne High School	271	1976
Stations Exceeding Federal Secondary Standard**		
St. John's College	178	1975
Fire Dept. HQ	184	1975
N.E. Police Station	203	1975
S.E. Police Station	204	1975
S.W. Police Station	161	1975
Ft. McHenry	182	1975
Fire Dept. #22	208	1975
Cockeysville	167	1975
Riviera Beach	174	1976
Fire Dept. HQ	188	1976
Fire Dept. #22	198	1976
Ft. McHenry Nat'l Park	255	1976
S.E. Police Station	214	1976
S.W. Police Station	157	1976
Spring Gardens	164	1976
AAI	230	1976
Edgemore Fire Station	235	1976
Essex	151	1976
Campbell Scale House (Texas)	155	1976
Sollers Point Vocational	185	1976

* Primary Standard = 260 $\mu g/m^3$.
** Secondary Standard = 150 $\mu g/m^3$.

The highest annual TSP concentrations for 1975 and 1976 were found at the Fire Department #10 and the Patapsco Sewage Treatment Plant (STP) located in the Fairfield and East Brooklyn areas of South Baltimore. The locations of the stations violating the 1975 and 1976 primary standards are shown on the map in Figure 1. The metropolitan Baltimore nonattainment area where violations for suspended particulates occurred is indicated in Figure 2. The high readings at the Patapsco STP are biased due to temporary heavy construction in the immediate vicinity of the monitor, according to the Maryland BAQNC. Therefore samples from the site are not suitable for developing control strategies.

The BAQNC operated, maintained and calibrated the three hi-vol stations used in this project. These hi-vol samplers are located at Fire Department #10, Fire Department #22 and Fort McHenry. These three stations are representative of the nonattainment area (Figure 2). The hi-vol filter sampling procedure followed is described in Appendix A. In addition, BAQNC has provided GEOMET with 18 hi-vol filters, 3 blank filters - 1 from Fort McHenry and 2 from Fire Department #22. Also, BAQNC personnel furnished reports detailing weather conditions and activities, such as construction, demolition or dumping operations during sampling periods occurring in the vicinity of each station.

The Environmental Protection Agency, Region III, has provided support and advice on hi-vol site selection, filter selection and criteria, and updated fugitive emission equations.

The scope of the work performed in each of five task areas is described below:

<u>Filter Analysis</u>

The filters were analyzed by IIT Research Institute. Physical and chemical analyses were performed on the hi-vol filters. The microscopical analysis identified types of particles by shape, mass, color, transparency, size, resiliency, and refractivity. In some cases particle concentration was determined by microscopy (stratified visual counting). Particle combustibility is determined by low temperature ashing. Plasma emission spectroscopy was used in determining the metal particulates. Sulfates were determined turbidimetrically. For details on sulfate, metals and particle mass determination, see Appendix F.

<u>Identification of Fugitive Emission Sources</u>

In 1977, BAQNC performed a ground area "windshield" survey (see Appendix E for survey form) of Baltimore City and surrounding areas of Baltimore and Anne Arundel Counties. The purpose of this survey was to identify potential fugitive emission sources. Types of surface material, such as percent grass cover, asphalt, and dirt and gravel, were identified along with amount of vehicle activity and type of industrial activity.

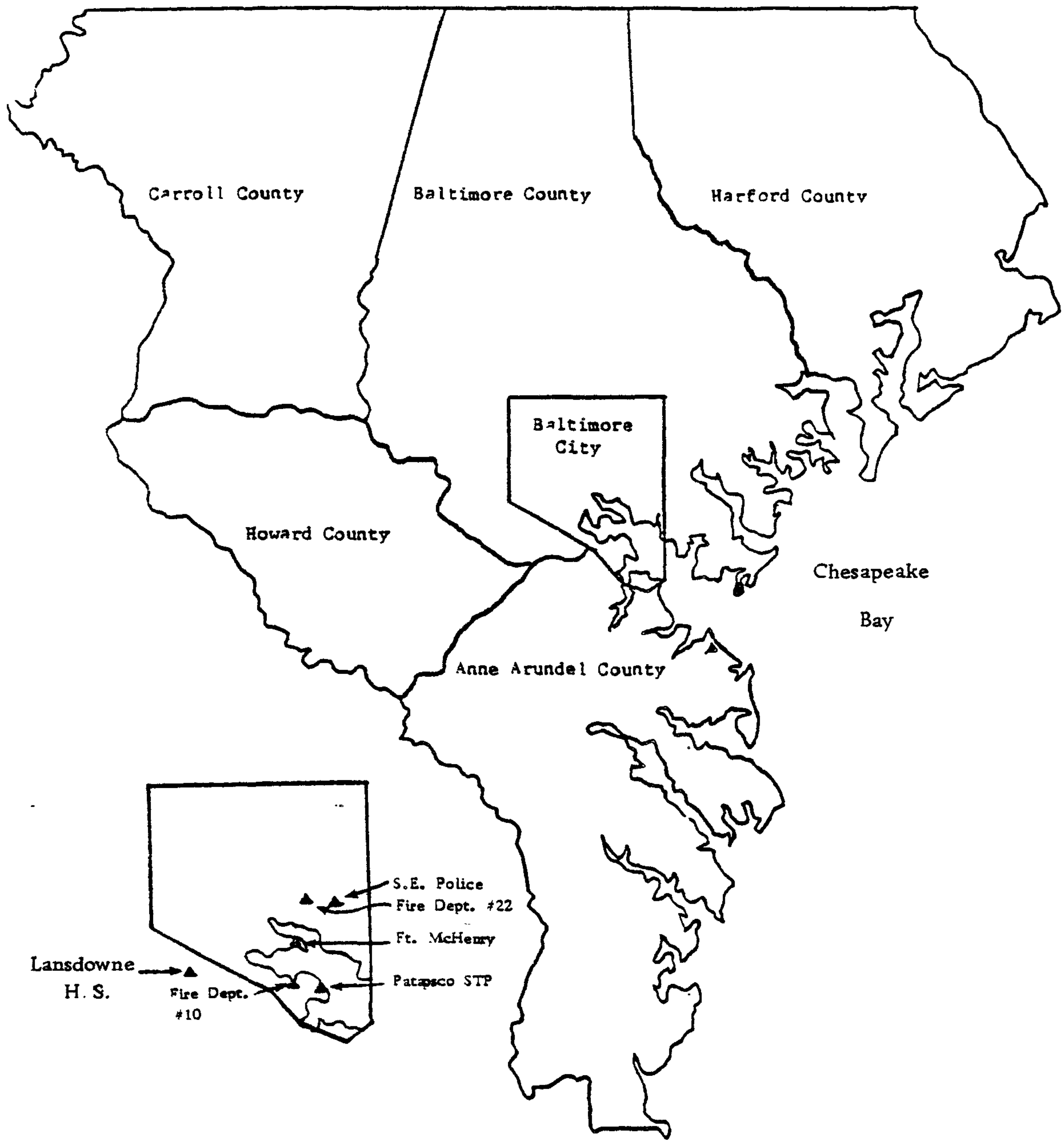

Figure 1. Location of TSP monitoring stations exceeding primary NAAQS in 1975 and 1976.

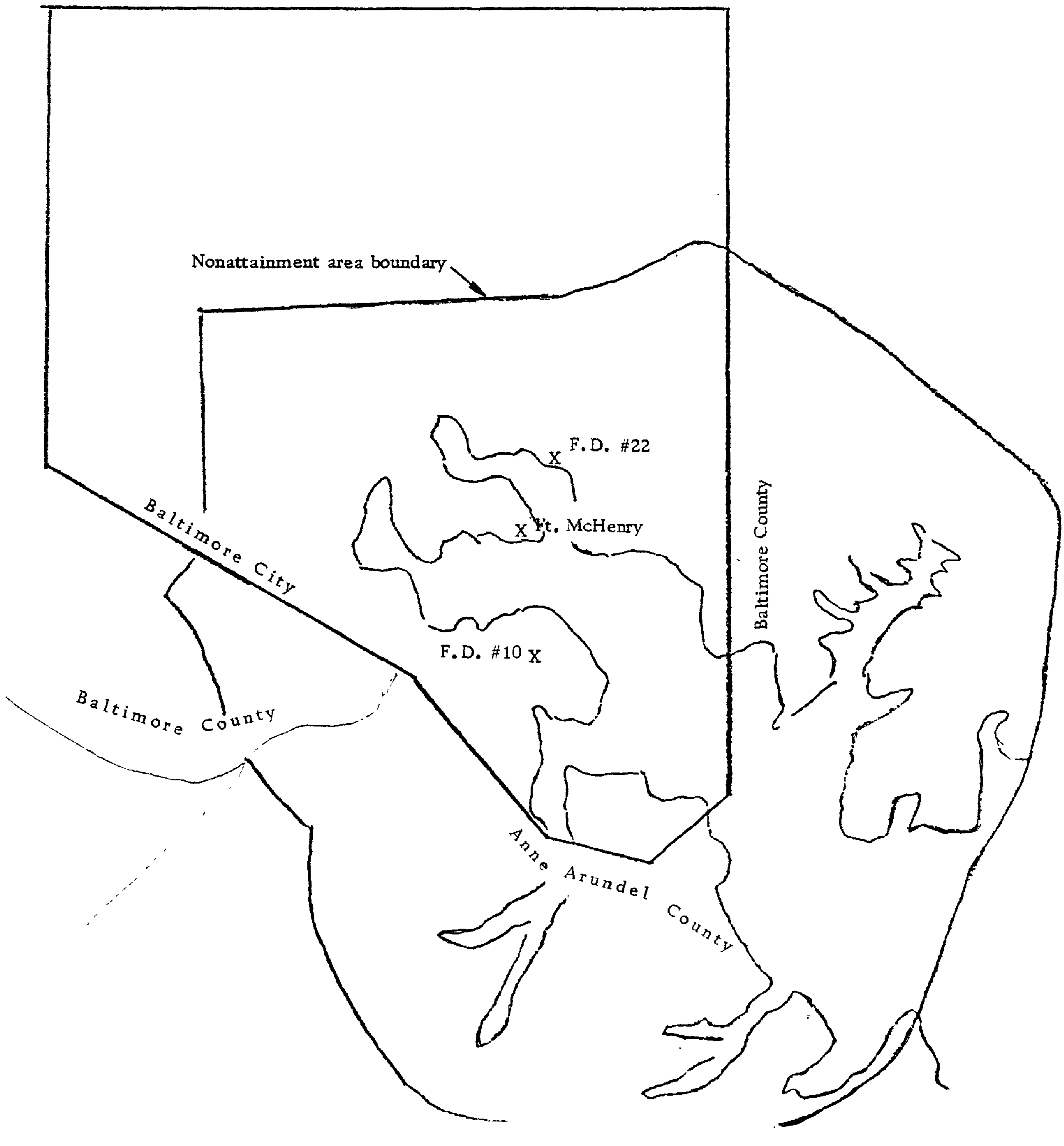

Figure 2. Metropolitan Baltimore nonattainment area for TSP, including the three hi-vol stations used in the project.

Types of particulates were identified by microscopy and chemical analyses of the hi-vol filters. Sources were then identified that emitted these kinds of materials.

Fugitive Emission Factors

Empirical equations have been developed in recent years to determine the particulate emission rates from various nontraditional fugitive sources. Some such sources are unpaved roads, active construction sites and wind erosion. The empirical equations are referenced in this report as fugitive particulate emission equations. More information on these equations is presented in Section 4.

Using the BAQNC survey results as input to a computer program which contains six fugitive particulate emission equations, source emission rates were calculated for paved roads, unpaved roads, construction sites, storage piles, wind erosion and railroads within Baltimore City and surrounding parts of Baltimore and Anne Arundel Counties.

Revision of State Emission Inventory

A fugitive particulate emission inventory has been prepared to supplement the existing Maryland emission inventory. This supplementary inventory consists of fugitive particulate emission factors, location of each source in UTM and Maryland coordinates, major point source fugitive emission rate tables, typical flue gas characteristics for industrial sources, size distribution graphs, and microscopy results which indicate types and concentrations of airborne-sampled materials.

Recommendation of Control Strategies

Appropriate control strategies have been selected for each of six types of fugitive particulate emission sources. The feasibility of implementation and the effectiveness of these control strategies have been included when possible.

SECTION 2

CONCLUSIONS

Microscopy and supporting chemical analyses of hi-vol filters from Fire Department #10, Fire Department #22, and Fort McHenry show that about 50 percent of the sampled TSP is mineral, and thus probably comes from nontraditional fugitive emission sources. According to our emission estimate, the most likely sources are wind- and vehicle-generated fugitive particulate emissions from dirt and gravel road surfaces. The remaining 50 percent of the material found on the filters is probably due to emissions from traditional sources including cornstarch from harbor grain transfer operations in the Fort McHenry area, slag particulate probably from operations within and around Bethlehem Steel plant on Sparrow Point, and sulfate generated by a combination of nearby industrial operations and distant combustion of sulfur-bearing fuels.

In 1975 and 1976 all of the MBIAQCR's 24-hour and annual TSP violations exceeded the appropriate standards by about a factor of two or less. About 50 percent of the sampled TSP is estimated to be from fugitive emission sources. Since available fugitive particulate control strategies are generally at least 60 to 80 percent efficient, proper application of the fugitive particulate control strategies can reduce TSP emissions by about 35 percent and will result in attainment of the 24-hour and annual TSP standards for most areas within the MBIAQCR.

The high concentrations of TSP in the vicinity of Fire Station #10 require a larger reduction. However, since fugitive sources account for more than 70 percent of the high-concentration material observed at this site, it appears that effective fugitive emission controls can achieve compliance at this site also.

SECTION 3

RECOMMENDATIONS FOR CONTROL STRATEGIES

The fugitive particulate emission estimates of this study indicate the magnitude of the various types of sources relative to one another and thus establish priorities for fugitive particulate emission source control strategies.

The seven fugitive particulate emission source categories within Baltimore City, ranked with largest emission rate first and decreasing to smallest emission rate last, are: dirt roads, gravel roads, active construction sites, storage piles, wind erosion, railroads and paved roads.

Because the largest emission rates are from dirt roads, gravel roads, and active construction sites, priority should be given to the control strategies for these TSP sources. Dirt road and gravel road emissions include active dirt and gravel parking lots. Active construction sites include waste disposal sites. Recommended control strategies for the three sources will be most effective in reducing TSP levels. Dirt roads should be either paved or oiled. This will reduce emissions by at least 85 percent. The paving of gravel roads will also reduce emissions by 85 percent. Construction site emissions should be controlled by using water, perhaps from sprinklers or tank trucks, to regularly wet exposed surface dust sources. Active waste disposal emissions should be controlled by covering the wastes with soil, planting vegetation and using water spray bars at dumping areas. These techniques will reduce emissions by 25 to 100 percent.

Control strategies for the other sources are also recommended. Storage pile emissions should be controlled by enclosing the piles with solid fencing or by covering with a tarpaulin. This should reduce emissions by 70 to 99 percent. Wind erosion emissions should be controlled by paving the surface, covering with soil and planting vegetation or by covering with granulated smelter slag, depending on the nature of the particular source. These techniques range in efficiency from 65 to 99 percent. Railroad emissions should be controlled by oiling track shoulders and covering open top railroad cars containing potentially wind-blown material. Paved road emissions should be reduced by adding curbs to streets. This will reduce dust by about a factor of four. Keeping roads in good repair will cut emissions by about 50 percent.

Section 4

FUGITIVE EMISSION ESTIMATES

The Maryland Bureau of Air Quality and Noise Control has recognized a need to update its emission inventory to include fugitive emissions. As a first step in this effort, the State, County, and Baltimore City control agencies joined in conducting a survey of nonconventional sources of fugitive emissions in the heart of the Metropolitan Baltimore Intrastate Air Quality Control Region (MBIAQCR). The survey covered the nonattainment area for total suspended particulates including 61 square miles over the city of Baltimore and 284 squares measuring 1000 feet on a side in parts of the surrounding Baltimore and Anne Arundel Counties which lie near the City of Baltimore. The total area covered by the survey is shown in Figure 2. The inspectors who performed the survey filled out the form shown in Appendix B for each source which he/she considered significant. The information from this survey formed an important and valuable input to the fugitive emission estimates derived in this study for the MBIAQCR.

In this study the survey data were used to calculate fugitive emission estimates which supplement particulate emissions from conventional sources. The new emission inventory includes both amount and size of fugitive particle emissions so that revised inventory can be used in modeling studies of the transport and dispersion of suspended particulate matter. Fugitive emission estimates were developed for both area sources (identified in the survey) and point sources which are already in the Maryland emission inventory. In the first step, a survey of emission factors for quality and particle size was made from the literature and from followup contacts with investigators currently measuring fugitive emissions. A discussion of the best estimates of both amount and particle size of all the types of fugitive emissions found in the Baltimore area is presented in this discussion. The last two parts of this section describe the fugitive emission estimates derived from area and point sources respectively, in the MBIAQCR.

Fugitive Particulate Emission Equations

Because fugitive particulate emissions were suspected as being significant contributors to the Federal TSP violations in Baltimore and surrounding areas, a literature search on fugitive particulate emissions equations was performed. Our literature search uncovered five suitable fugitive particulate emission factor equations. The equations are for paved roads, unpaved roads, construction sites, storage piles and wind erosion. A sixth equation for railroad fugitive emissions was developed from the unpaved road equation. The emission factors are for particles with an aerodynamic diameter of less than 30 μm.

Paved Roads--

An equation for emission factors for paved roads was formulated after reviewing results from a monitoring program conducted by Midwest Research Institute (Bohn et al. 1978) and after extensive consultation with Chatten Cowherd, Jr. of Midwest Research (MRI). When assuming light duty vehicles, the equations used by us and MRI are almost identical. The following fugitive particulate emission equation was used:

$$EF = 0.45 \left(\frac{s}{10}\right) \left(\frac{L}{5000}\right) \left(\frac{W}{3}\right)$$

where EF = emission factor (lb/vehicle mile travelled)

s = silt content of road surface material (%)

W = average vehicle weight (tons)

L = surface dust loading on traveled portion of road (lb/mile).

In general there was not sufficient information available to assign values to the above parameters. The following values were selected as representative values for the Baltimore area:

s = 12%

W = 1.5 tons

L = 17.7 lb/mile.

These values result in an emission factor for Baltimore paved roads of 0.43g(9.6×10^{-4} lb) per vehicle mile travelled.

A single representative surface soil silt content for general application to the Baltimore area was determined for paved and gravel roads and for railroad beds. Based on contaminants measured in street runoff (Sartor and Boyd 1972), the silt content of mineral-like matter was found to be 5 to 15 percent. A value of 12 percent was selected as representative of this range because it is compatible with the EPA recommendations for gravel material.

On paved roads, the traffic is estimated to be primarily light-duty vehicles. The average weight is assumed to be 1 to 5 tons for these vehicles. The accuracy of this estimate cannot be quantitatively assessed. The equation was derived from a limited number of accurate field tests and includes extrapolation of parameter values from measurements not made in the Baltimore area.

Unpaved Roads (Gravel and Dirt)--

The emission factors selected for gravel and dirt roads is given by the following relationship* (EPA 1977):

$$EF = 0.60\ (0.81)\ s\ (\frac{S}{30})\ (1 - (\frac{P}{365}))\ (453.6)$$

where EF = emission factor, g per vehicle mile travelled

s = silt content (%)

S = average vehicle speed, mph

P = days per year with 0.01 inch or more of precipitation or reported snow cover.

The following parameter values were selected as being representative for the Baltimore area:

s = 12 % for gravel roads. (See Table 4 and Figure 3 for dirt roads.)

S = 10 mph for parking lots, and 25 mph for roads, unless otherwise stated. (See Appendix C.)

P = 112 days/year.

Active dirt and gravel parking lots are analyzed as dirt and gravel roads, respectively. The length of these "roads" is calculated by dividing the parking lot square footage by 2 to get the active area of the lot, then dividing the result by 20 feet (width of road) to get the length of road. Paved parking lots are neglected because of their minor particulate emissions.

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* The equation contains a factor of 0.6 to produce an emission estimate representing particles in sizes generally measured by hi-vol samplers, i.e., less than 30 μm in diameter. Experimental tests show: (1) that the collection efficiency of hi-vols for particles greater than 10 μ depends on the orientation of the wind to the samples and (2) that, for some orientations, collection efficiencies as large as 34 percent are observed for 50 μm diameter particles (Wedding et al. 1977).

The estimate of 12 percent silt content for gravel roads is from the standard EPA emission factors (EPA 1977). The vehicle speeds are selected estimates for use when other data are not available. The number of precipitations and/or snow cover days is an average observed at Baltimore-Washington International Airport for the years 1972 through 1976.

The emission factor for gravel and dirt roads and parking lots includes particles with aerodynamic diameters less than 30 μm. To get total emissions of all particulates, including particles larger than 30 μm, the above emission factor should be multiplied by 1.67. The relationship is estimated to be accurate to within ± 20% (EPA 1977).

Construction Sites--

The selected emission factors for construction sites is 1.2 ton/acre/month (269 g/m^2/month) (Cowherd et al. 1974). Activity levels, which are difficult to estimate without precise information on the construction activity, can change this emission estimate by a factor of 2 or more.

Active solid waste disposal sites with no burning are treated as construction sites because of the similarity of the activity to construction operations. No other basis for emission estimates was determined.

The emission factor applies only to the number of active acres of construction activity. The emission factor is for medium-type construction (townhouses, shopping centers). The emission factor represents the high end of the emission range because it was developed in the desert Southwest United States. A 30 percent silt and Thornthwaite's Precipitation-Evaporation Index (PE) of 50 is assumed. The emission factor is for particles with an aerodynamic diameter less than 30 μm and a particle density of 2 to 2.5 g/cm^3.

Aggregate Storage Piles--

For storage piles of aggregates, the following emission factor was selected (Cowherd et al. 1974).

$$EF = \frac{0.33}{\left(\frac{PE}{100}\right)^2} \quad (0.5)$$

where EF = emission factor, g per kg of material placed in storage

PE = Thornthwaite's precipitation-evaporation index.

For Baltimore, the value of Thornthwaite's index is 108 (see EPA 1977).

Only large storage piles are treated in this study. If information is not available on the throughput of material, a rate of 100,000 tons per year is assumed.

In addition to the standard inventory of industrial aggregate storage piles, railroad satellite yard loading and unloading operations have been included as sources to which the aggregate storage pile emission factor is applicable. The emission factor relationship is supported by limited test data and engineering judgment.

Wind Erosion--

An equation to estimate fugitive emissions due to wind erosion of exposed areas was selected from a recent analysis (Bohn et al. 1978):

$$EF = 3400 \left(\frac{e}{50}\right)\left(\frac{s}{15}\right)\left(\frac{f}{25}\right)\left(\frac{PE}{50}\right)^{-2} (0.112)$$

where EF = emission factor, $g/m^2/yr$

e = surface erodibility (tons/acre/year)

s = silt content of surface material (%)

f = frequency that wind speed exceeds 12 mph (%)

PE = Thornthwaite's precipitation-evaporation index.

The soil erodiblity and silt content were estimated for each of four quadrants using data available from U.S. Soil Conservation Service surveys for Baltimore County (1970) and Anne Arundel County (1968) and from estimates of erodibility determined experimentally (Cowherd et al. 1974) for each soil type (see Table 3). The estimates were derived by extrapolating the data available for outlying county land into the city limits. The values determined by quadrant and corresponding grid square are listed in Table 4. The area included in each quadrant is shown in Figure 3.

The percent of time the wind exceeds 12 mph was estimated from the climatological data used by Maryland BAQNC to model air quality and is based on observations at Baltimore-Washington International Airport (Maryland BAQNC 1976). A value of 21.4 percent was determined to be appropriate. As previously discussed, the Thornthwaite index is 108 for Baltimore.

The wind erosion emission factor is applied to the entire surface area of the active and unused dirt parking lots, inactive gravel lots and active and unused dirt roads within Baltimore City and Baltimore and Anne Arundel Counties. The wind erosion emission factor is also applied to the exposed surface of aggregate material contained in uncovered railroad cars (parked and moving); however, railroad beds are not included.

TABLE 3. SOIL ERODIBILITY FOR VARIOUS SOIL TEXTURAL CLASSES (Cowherd 1974)

Predominant soil textural class	Erodibility, I, tons/acre/year
Sand*	220
Loamy sand*	134
Sandy loam*	86
Clay	86
Silty clay	86
Loam	56
Sandy clay loam*	56
Sandy clay*	56
Silt loam	47
Clay loam	47
Silty clay loam	38
Silt	38

* Very fine, fine, or medium sand

TABLE 4. BALTIMORE ERODIBILITY AND SILT CONTENT

Quad No.	Grid No.	Average Erodibility (tons/acre/year)	Surface Soil Average Percent Silt
1	None	49	75
2	38, 39, 40	53	72
3	41-45, 51-55, 61-65, 72-75, 84, 85, 95	52	62
4	46-50, 56-60, 66-70, 76-80, 86-90, 96-98, 106-109, 117-120	55	65

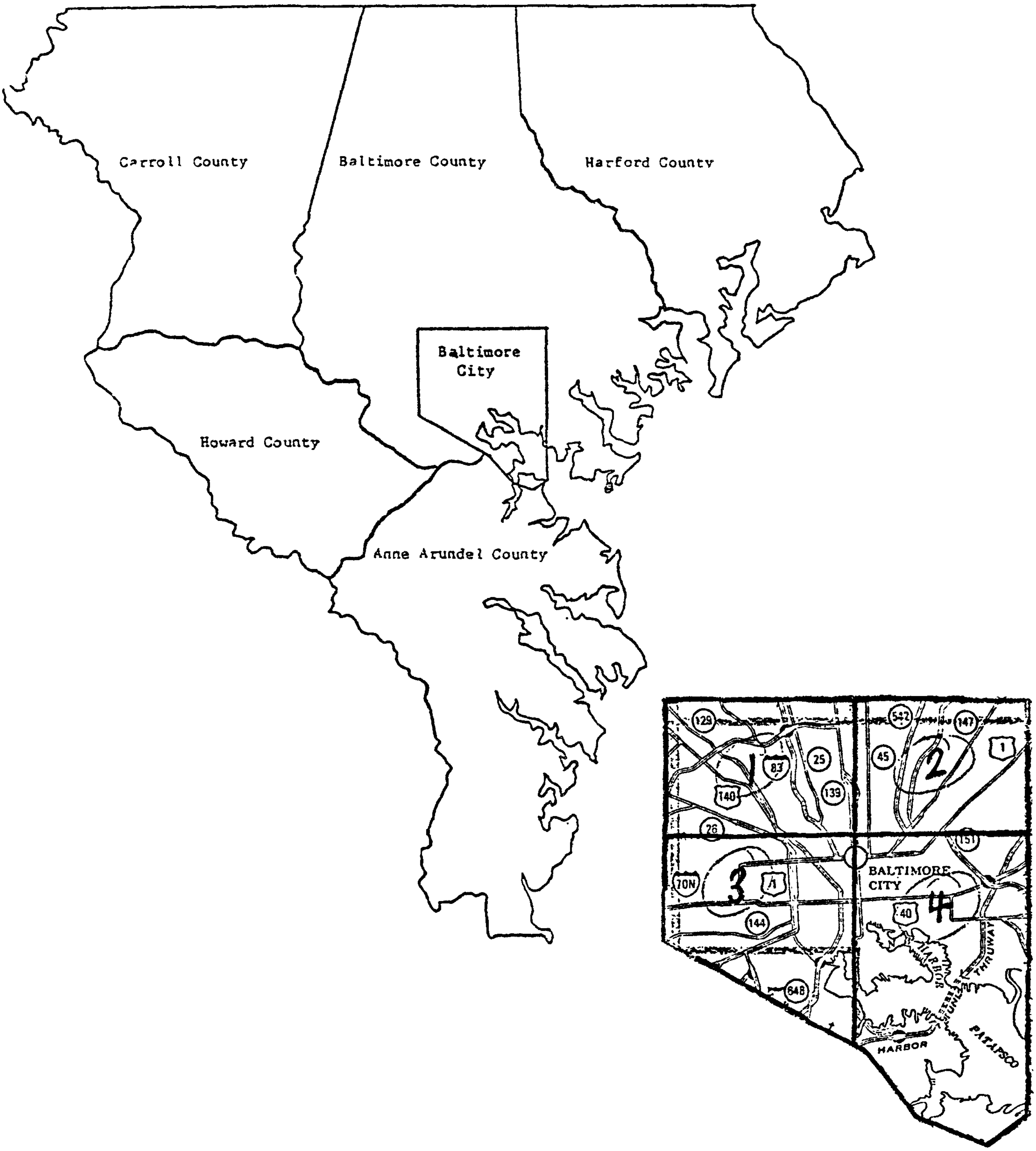

Figure 3. Baltimore City surface soil silt and erodibility quadrants.

The emission factor is based on a limited number of measurements of undetermined accuracy. It is considered the best available estimate but its accuracy is unknown because the relationship is based on an insufficient broad data base. It is considered primarily applicable to particles less than 30 μm in diameter and with a density 2 to 2.5 g/cm^3.

Railroads--

Fugitive emissions from railroads are estimated on the assumption that they are related to the same factors which are applicable to unpaved roads. Since railroad cars do not contact the underlying ground surface, the assumption was made that the emissions are only 10 percent of the emissions associated with highway vehicles. The following relationship is used:

$$EF = 0.1\ (0.60)(0.81)s\left(\frac{S}{30}\right)\left[1 - \left(\frac{P}{365}\right)\right](453.6)$$

where EF = emission factor, g per vehicle mile travelled

s = silt content (%)

S = Average vehicle speed (mph)

P = days per year with 0.01 inch or more of precipitation or reported snow cover.

The following parameter values are selected as being representative for the Baltimore area:

s = 12%

S = 15 mph and 40 mph for railroads within Baltimore City, and outside of the City, respectively, unless otherwise stated (See Appendix C.)

P = 112 days/year for Baltimore.

The equation is based on conversations with railroad personnel and educated judgment because no fugitive emission equations for railroads could be found. No particle size information for railroad emissions is available. However, it is judged that the emissions are similar to those from unpaved roads and that particle sizes and densities would be similar to emissions from that type of source.

Summary--

Table 5 contains a summary of the fugitive emission factors compiled for the Baltimore area for each of the seven types of nontraditional fugitive emission sources. The table also identifies the type of information about the sources which is required to apply the factor.

TABLE 5. SUMMARY OF FUGITIVE EMISSION FACTORS AND REQUIRED SOURCE DATA

Type of Source	Emission Factor	Required Source Characteristics
Paved road	0.43 (g/VMT) 0.96 x 10^{-3} (lb/VMT)	VMT (vehicle miles travelled)
Gravel road	61 S (g/VMT) 0.13 S (lb/VMT)	VMT S (vehicle speed, mph)
Dirt road	5.1 sS (g/VMT) 0.0112sS (lb/VMT)	VMT S s (silt content of road material, %)
Construction sites	9.0 (g/m^2/day) 79 (lb/acre/day)	Site area
Wind erosion	2.6 x 10^{-4} e s (g/m^2/day) 2.3 x 10^{-3} e s (lb/acre/day)	Area s e (surface erodibility, ton/acre/year
Railroads	6.1 S (g/VMT) 0.013 S (lb/VMT)	VMT S
Storage piles	0.14 (g/kg) 0.28 (lb/ton)	Quantity placed in storage

Fugitive Particulate Size Distribution

Airborne fugitive particulate size distribution data have been developed for various road surfaces, for many industrial operations, and for crushed stone and other stockpile aggregate loading operations. Particle size distribution information has been obtained in terms of the mass median diameter, the particle density, the percentage of particles less than 30 μm, and the principal chemical compound present.

The particle size distribution estimates are based on measurements with various types of collection devices for distinguishing sizes, but primarily with multistage cascade impactors. Much of the reported data was obtained by Midwest Research, Incorporated using a Sierra Instruments hi-vol parallel-slot cascade impactor with a cyclone preseparator to remove coarse particles. The MRI intake was isokinetic for a 4.5 m/sec (10 mph) wind speed. Generally, source samples were taken within 10 meters of the source.

The particle size and density have important bearings on the particle suspension process in which the forces of turbulence and gravity interact to keep particles airborne or to impact them on the ground and other surfaces. A set of data has been compiled which represents the nature of the particle size distribution which is required to represent aerosol dynamics and which is compatible with the available measurments. Table 6 is a compilation of 16 types of particulate emissions which have been measured. A list of much less complete particle size information which describes emissions from a aggregate stockpile loading operations is given in Table 7.

Although no particle size measurements were found for construction sites, wind erosion, or railroad yards, the particle size distribution for those types of sources can be estimated from other sources which are estimated to have similar particles. It is recommended that results for agricultural tilling seems reasonably applicable to construction operations since both involve heavy equipment in earthmoving operations. The same data is recommended for wind erosion only because a more applicable set of data was not found. The data for gravel roads is recommended for railroad operations for the same reason.

The particle size data avilable for roadway emissions was repeated in two of these tests, each of which produced similar results. These results are very limited and the general applicability of these results, which were measured in Kansas City, to Baltimore is reasonable but a matter of conjecture until data is made in Baltimore or at least in additional locations. The remaining nonroadway sources can be grouped into one of three classes: (1) Insufficient information, designated NA in Table 6, (2) Highly variable particle sizes, designated variable in Table 6, and (3) Reasonably consistent which applies to the remaining three categories of fugitive sources (i.e., pulverized coal combustion, cement kilns, and municipal incinerators).

TABLE 6. MASS MEDIAN DIAMETER (MMD) AND PERCENTAGE OF EMISSION LESS THAN 5 AND 30 MICRONS FOR FUGITIVE SOURCES

Source	Particle Density g/cm^3	MMD (μm)	<5 μm (%)	<30 μm (%)	Notes
Concrete roads*	2.8	3.9	61	94	Mean of 3 tests
Asphalt roads*	1.3	5.9	42	90	Mean of 2 tests
Gravel roads*	2.5	19.	23	62	Mean of 3 tests
Dirt Roads*	2.5	81.	9	32	Mean of 3 tests
Agricultural tilling***			35	80	
Pulverized coal combustion**	2.3	13.	25	75	43% SiO_2
Stoker Coal combustion**	NA	58.	4	27	
Basix O_2 furnace**	3.4	0.1	NA	NA	85-95% <1 μm 90% Fe_2O_3
Open hearth furnace**	5.0	5.	50	NA	85-90% Fe_2O_3
Electric arc furnace** (variable)	3.8	2.5	60	98	30% Fe_2O_3
Coke ovens**	NA	NA	NA	90	
Cement kiln**	2.9	12.	23	77	45% CaO
Municipal incinerator**	2.8	21.	6	69	35%SiO_2
Iron Foundry**	2.8	NA	10	29	30% SiO_2
Kraft pulp recovery furnace**	NA	NA	NA	NA	50-85% <2 μm 80% Na_2SO_4
Asphalt rotary dryer (variable)**	2.6	9.	40	70	Highly variable
Crushed stone stockpiling***	2.5	1.4	90	NA	

* Reference: Galkiewicz and Lynn 1976.
** Reference: Vandergrift 1971.
*** Reference: Cowherd et al. 1974.
NA - Not available.

TABLE 7. STOCKPILE FUGITIVE PARTICULATE EMISSIONS - SIZE AND DENSITY INFORMATION

Stockpile Material	Diameter of Emitted Particulates (μm)[1]	Density (gm/cm^3) or Specific Gravity[2]
Gravel or Crushed Stone	90% <5	2.5 density
Sand	50% are 2-15	2 density
Coal	1-10 mean diameter	1.4 density
Oyster Dust	Not available	2.8 spec. grav.
Manganese Ore	Not available	3 spec. grav.
Iron Ore	Not available	4 spec. grav.
Concrete	10-20% by weight < 5	2.8 density
Stone	50-70% < 4	Not available
Road Salt	Not available	2.2 density
Chrome Ore	Not available	3 spec. grav.
Ferrochrome Ore	Not available	3 spec. grav.
Ferromanganese Ore	Not available	3 spec. grav.
Batterymanganese Ore	Not available	3 spec. grav.
Sand Blasting Grit	Not available	2 density
Cinder Blocks	Not available	2 density

[1] Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions, PEDCo, March 1977. pp. 2-57, 2-221, 2-316, 2-327.

[2] CRC Handbook of Chemistry and Physics, 53rd Edition, 1972-73. Section B, "Physical Constants of Inorganic Compounds."

Fugitive Particulate Area Source Emissions

Seven types of sources of fugitive emissions were identified from an examination of the results of the survey of fugitive dust sources conducted by the Maryland BAQNC. Emission factors for estimating emissions for these sources are listed in Table 5, along with the source parameters required to derive emission estimates.

Within the City of Baltimore the location of sources in the survey was identified by grid squares, each of which consisted of about a square mile area. The survey covered the designated nonattainment area for suspended particulate matter. Fugitive emissions have been estimated for all seven types of sources in 61 grid squares covered by the survey.

Within the parts of the nonattainment area lying in Anne Arundel and Baltimore Counties, sources were identified by square areas 1000 feet on a side. Emission estimates were determined for each of the seven types of fugitive sources for 284 such square areas.

Table 8 lists the emission estimates determined for 61 1-mile square areas within the City of Baltimore. The total of fugitive emissions within the surveyed area of the city is 80 metric tons (88 English tons) per day. Most of these emissions are from gravel roads (29%) and dirt roads (51%). The emissions from paved roads and railroads are negligible in comparison. Construction sites, storage piles and wind erosion make up the remaining emissions by providing 11 percent, 5 percent and 2 percent, respectively.

In the nonattainment area within the adjacent counties the surveyed, fugitive emissions are estimated to be 30 metric tons (33 English tons) per day (see Table 9). Gravel roads contribute 38 percent to this estimate, dirt roads 17 percent, and construction sites 26 perent. Storage piles and wind erosion contribute the remaining 6 and 13 percent, respectively.

A listing of the source characteristics by grid square which were used to compute the fugitive emission estimates is presented in Appendix C. A sample survey form which was used to record information by survey personnel is shown in Appendix B. Information from the survey forms was coded on cards and entered into a program to compute emissions. A listing of the programs used to compute emissions is presented in Appendix D.

Fugitive Emissions Information for Point Sources

Table 10 contains fugitive emission information for point sources in the Maryland emission inventory which lie in the MBIAQCR, which emit 100 tons per year or more, and which correspond to processes for which fugitive emission data is available. Other fugitive emissions are

TABLE 8. BALTIMORE CITY FUGITIVE DUST EMISSION BY SOURCE TYPE

MD. COORDINATES FEET X	MD. COORDINATES FEET Y	GRID NO.	PAVED ROADS LB/DAY	GRAVEL ROADS LB/DAY	DIRT ROADS LB/DAY	CONSTR SITES LB/DAY	STORAGE PILES LB/DAY	STORAGE PILES TYPE	WIND EROSION LB/DAY	RAILROADS LB/DAY	RAILROADS LB/VMT	TOTAL LB/DAY
922105.	541315.	38	38.90	297.79	0.00	0.00	0.00		45.76	0.	0.00	382.45
927370.	541315.	39	52.38	0.00	113.20	788.06	77.51	22	74.17	0.	0.00	1105.32
932630.	541315.	40	36.89	6.74	26.68	0.00	0.00		0.00	0.	0.00	70.31
884740.	535920.	41	38.61	0.00	0.00	0.00	0.00		0.00	0.	0.00	38.61
890265.	535920.	42	46.93	0.00	0.00	0.00	0.00		0.00	0.	0.00	46.93
895525.	535920.	43	53.81	285.67	1086.15	0.00	77.51	25	111.75		0.20	1614.89
900790.	535920.	44	50.18	63.33	1157.86	29.44	77.51	20	329.39		0.20	1707.72
906185.	535920.	45	84.97	37.73	0.00	245.48	77.51	29	70.08		0.20	515.77
								31				
								22				
911580.	535920.	46	114.89	1290.89	18.25	968.38	77.51	20	4.26		0.20	2474.18
								21				
916840.	535920.	47	91.82	367.86	109.49	848.75	77.51	20	5.61		0.20	1491.04
								21				
922105.	535920.	48	70.25	284.32	0.00	31.70	0.00		60.40		0.20	446.68
927370.	535920.	49	61.08	180.58	32.85	0.00	0.00		63.57	43.		381.92
932630.	535920.	50	32.02	1231.60	22043.81	0.00	0.00		38.74		0.20	23346.18
884740.	530525.	51	63.94	0.00	0.00	0.00	0.00		0.00	0.	0.00	63.94
890265.	530525.	52	36.80	0.00	0.00	0.00	0.00		0.00	0.	0.00	36.80
895525.	530525.	53	52.66	757.29	1970.39	0.00	77.51	24	92.97		0.20	2950.82
								23				
900790.	530525.	54	53.62	358.43	0.00	958.48	77.51	21	32.39		0.20	1480.43
								20				
906185.	530525.	55	118.04	47.16	13103.43	2425.86	77.51	20	253.58	16.		16042.29
								21				
								22				
								32				
911580.	530525.	56	138.11	2228.74	1459.88	334.25	77.51	20	73.51		0.20	4312.00
								21				
								33				
916840.	530525.	57	61.46	0.00	0.00	0.00	0.00		26.19	0.	0.00	87.64
922105.	530525.	58	51.80	2336.54	43.80	0.00	0.00		81.78		0.20	2513.92
927370.	530525.	59	43.30	1024.09	34.60	0.00	0.00		427.93	1.		1531.80
932630.	530525.	60	28.39	1040.26	0.00	126.81	0.00		228.19	1.		1425.53
884740.	525265.	61	28.39	0.00	0.00	0.00	0.00		0.00	0.	0.00	28.39
890265.	525265.	62	35.17	0.00	0.00	0.00	0.00		0.00	0.	0.00	35.17
895525.	525265.	63	43.01	14.82	34.81	937.52	0.00		172.07		0.20	1202.19
900790.	525265.	64	67.48	661.62	0.00	857.51	0.00		64.84	33.		1684.86
905185.	525265.	65	74.17	1712.65	5331.33	729.94	77.51	20	193.55		0.20	8119.15
								21				
911580.	525265.	66	60.88	2308.24	233.58	256.95	0.00		80.82		0.20	2940.48
916840.	525265.	67	26.95	1643.93	2463.55	103.87	77.51	21	40.79	57.		4414.00
922105.	525265.	68	43.97	464.75	47.74	57.37	77.51	20	275.62	8.		1041.04
								21				
								27				
								28				
							65.78	30				

(continued)

TABLE 8. BALTIMORE CITY FUGITIVE DUST EMISSION BY SOURCE TYPE (continued)

MD. COORDINATES FEET X	MD. COORDINATES FEET Y	GRID NO.	PAVED ROADS LB/DAY	GRAVEL ROADS LB/DAY	DIRT ROADS LB/DAY	CONSTR SITES LB/DAY	STORAGE PILES LB/DAY	STORAGE PILES TYPE	WIND EROSION LB/DAY	RAILROADS LB/DAY	RAILROADS LB/VMT	TOTAL LB/DAY
927370.	525265.	69	43.30	41.77	13547.68	738.24	77.51	21	175.33		0.20	14623.83
932630.	525265.	70	28.39	25.60	0.00	0.00	0.00		0.00	0.	0.00	53.99
890265.	519870.	72	11.85	0.00	0.00	0.00	0.00		0.00	0.	0.00	11.85
895525.	519870.	73	24.56	272.87	814.61	362.33	0.00		175.55		0.34	1649.92
900790.	519870.	74	46.17	115.88	0.00	40.01	77.51	20	0.00		0.20	279.57
								21				
906185.	519870.	75	32.31	499.92	1107.04	3019.40	77.51	20	13.83	0.	0.00	4750.00
								21				
911580.	519870.	76	12.71	187.30	7.30	0.00	77.51	21	15.80	18.		345.73
							26.31	30				
916840.	519870.	77	12.71	1346.14	0.00	1350.03	77.51	22	22.45	28.		2837.54
922105.	519870.	78	40.62	877.21	3983.57	0.00	77.51	20	100.02	8.		5153.02
								21				
								26				
								28				
								35				
							65.78	30				
927370.	519870.	79	43.30	5328.49	16058.67	90.58	77.51	21	257.45		0.20	21856.01
932630.	519870.	80	28.39	3096.52	2262.81	0.00	0.00		16.34		0.20	5404.06
895525.	514475.	83	2.68	0.00	0.00	0.00	0.00		0.00	0.	0.00	2.68
900790.	514475.	84	21.60	3547.93	0.00	0.00	77.51	20	0.00		0.20	3647.04
								21				
906185.	514475.	85	40.43	0.00	34.81	3019.40	77.51	34	261.63		0.20	3433.78
911580.	514475.	86	45.30	1308.41	1219.00	44.69	77.51	20	6.03		0.20	2700.94
								21				
916840.	514475.	87	31.45	0.00	0.00	0.00	77.51	20	0.00		0.20	108.96
								21				
								35				
922105.	514475.	88	43.30	561.90	1350.39	0.00	77.51	23	60.76		0.13	2093.86
932630.	514475.	90	28.39	0.00	0.00	0.00	0.00		0.00	0.	0.00	28.39
906185.	509340.	95	4.01	0.00	0.00	0.00	0.00		0.00	0.	0.00	4.01
911580.	509340.	96	26.48	1633.15	0.00	52.84	77.51	20	0.72	0.	0.00	1790.69
								21				
916840.	509340.	97	31.45	1413.51	0.00	0.00	77.51	20	100.39	137.		7680.79
								21				
							5262.31	25				
							657.79	30				
922105.	509340.	98	31.45	8017.54	0.00	0.00	77.51	20	0.00		0.20	8126.49
								21				
								23				
911580.	504080.	106	6.40	0.00	233.59	0.00	0.00		38.77	0.	0.00	278.75
916840.	504080.	107	26.48	52.55	0.00	710.23	77.51	20	1.73		0.20	868.50
								21				
								23				
922105.	504080.	108	31.45	129.36	0.00	0.00	77.51	20	0.00		0.20	238.32
								21				

(continued)

TABLE 8. BALTIMORE CITY FUGITIVE DUST EMISSION BY SOURCE TYPE (continued)

MD. COORDINATES FEET X	Y	GRID NO.	PAVED ROADS LB/DAY	GRAVEL ROADS LB/DAY	DIRT ROADS LB/DAY	CONSTR SITES LB/DAY	STORAGE PILES LB/DAY	STORAGE PILES TYPE	WIND EROSION LB/DAY	RAILROADS LB/DAY	RAILROADS LB/VMT	TOTAL LB/DAY
927370.	504080.	109	31.45	0.00	0.00	0.00	0.00		238.58		0.20	270.02
916840.	498815.	117	13.09	4.10	0.00	0.00	0.00		10.65		0.20	27.84
922105.	498815.	118	24.76	301.84	0.00	0.00	0.00		0.00		0.20	326.59
927370.	498815.	119	26.48	4012.81	0.00	0.00	77.51	20 21	0.00		0.20	4116.80
932630.	498815.	120	14.81	474.31	0.00	0.00	77.51	20 21	0.00		0.20	566.64
TOTAL			2596.62	51894.14	83930.86	19128.12	8558.37		4343.95	357.06		176809.1

(continued)

TABLE 8. BALTIMORE CITY FUGITIVE DUST EMISSION BY SOURCE TYPE (concluded)

TYPE OF MATERIAL IN STORAGE PILES

20	FINE MATERIAL
21	COARSE MATERIAL
22	DIRT
23	GRAVEL
24	SAND
25	COAL
26	OYSTER DUST
27	MANGANESE ORE
28	IRON ORE
29	TRASH
30	ORE PILES
31	CONCRETE
32	STONE
33	METAL
34	UNKNOWN
35	ROAD SALT
36	CHROME ORE
37	FERROCHROME ORE
38	FERROMANGANESE ORE
39	BATTERYMANGANESE ORE
40	SANDBLASTING GRIT
41	CINDER BLOCKS

EACH GRID IS ONE SQUARE MILE. GRIDS 1 THROUGH 120 MAKE UP BALTIMORE CITY. THE BAQNC SURVEY WITHIN BALTIMORE CITY COVERS ONLY GRIDS 38-40, 43-50, 53-60, 63-70, 73-80, 84-88, 90, 96-98, 106-109, AND 117-120 AS CONTAINED ON THE CITY OF BALTIMORE, DEPT. OF PUBLIC WORKS, BUREAU OF ENGINEERING INDEX MAP. THE MARYLAND COORDINATES ARE TAKEN AT THE CENTER OF EACH GRID.

THE PAVED ROAD EMISSIONS ARE BASED ON 1975 REGIONAL PLANNING COUNCIL ESTIMATES OF AVERAGE WEEKDAY VEHICLE-MILES-OF-TRAVEL (VMT) WHICH INCLUDES AUTO TRAVEL ON FREEWAYS AND ARTERIAL ROADS. TRUCK TRAVEL, INTRA-RPD (REGIONAL PLANNING DISTRICT) TRAVEL, AND OTHER TRAVEL ON LOCAL AND COLLECTOR STREETS ARE NOT INCLUDED.

THE RAILROAD EMISSIONS ARE BASED ON 1/10 OF THE EMISSIONS PRODUCED BY THE GRAVEL ROAD EQUATION. FOR THE MAJOR RAILROAD SATELLITE YARDS LISTED BELOW, A SILT CONTENT OF 30% AND AN ERODIBILITY OF 50 TONS/ACRE/YR IS ASSUMED IN THE WIND EROSION EQUATION FOR BOTH EXPOSED COAL AND ORE. WHEN NO RAILROAD VMT ARE AVAILABLE JUST THE APPROPRIATE EMISSION FACTOR IS PRINTED. ALL RAILROAD EMISSIONS (LB/DAY) ARE DUE TO THE MAJOR SATELLITE YARDS ONLY. THERE MAY BE OTHER RAILROAD TRACKS IN THE SAME GRID THAT WEREN'T INCLUDED IN THE EMISSION ESTIMATE. THE MAJOR RAILROAD SATELLITE YARD VMT ARE CALCULATED BASED ON INFORMATION FURNISHED BY THE RAILROAD COMPANIES.

GRID NO.	SATELLITE YARD
49	BAYVIEW
55, 64	MT. CLARE
59, 60	ORANGEVILLE CONRAIL
67, 77	LOCUST POINT
68, 78	CANTON YARD
76	PORT COVINGTON
97	CURTIS BAY

ALL FUGITIVE EMISSION EQUATIONS ARE FOR PARTICLES WITH AN AERODYNAMIC DIAMETER <30 MICRONS.

FOR GRID NUMBERS 68, 76, 78 AND 97 ACTUAL THROUGHPUT RATES WERE USED FOR STORAGE PILES INSTEAD OF THE OTHERWISE ASSUMED 100,000 TONS/YEAR THROUGHPUT RATE.

THE DIRT AND GRAVEL ROAD VMT ARE CALCULATED TO INCLUDE DIRT AND GRAVEL PARKING LOTS, AND ARE BASED ON THE BAQNC SURVEY INFORMATION. ALL OTHER INPUT INFORMATION EXCEPT SOIL SILT CONTENTS AND ERODIBILITIES, AND RAILROAD AND PAVED ROAD VMT WERE FURNISHED BY THE BAQNC SURVEY.

TABLE 9. BALTIMORE AND ANNE ARUNDEL COUNTIES FUGITIVE DUST EMISSIONS BY SOURCE TYPE

MD. THOU. FT. X	MD. THOU. FT. Y	UTM THOU. MET. X	UTM THOU. MET. Y	GRAVEL ROADS LB/DAY	DIRT ROADS LB/DAY	CONSTR SITES LB/DAY	STORAGE PILES LB/DAY	STORAGE PILES TYPE	WIND EROSION LB/DAY	RAILROADS LB/VMT	TOTAL LB/DAY
891	509	355	4343	13.47	0.00	0.00	77.51	21	29.67	0.00	120.65
891	510	355	4343	0.00	0.00	0.00	0.00		0.00	0.54	0.00
891	513	355	4344	10.11	0.00	0.00	0.00		3.77	0.00	13.87
891	515	355	4345	0.00	0.00	0.00	77.51	34	67.31	0.00	144.82
892	508	355	4343	0.00	0.00	0.00	0.00		4.05	0.00	4.05
892	510	355	4343	0.00	0.00	0.00	0.00		2.77	0.54	2.77
892	512	355	4344	0.00	0.00	65.22	0.00		0.00	0.00	65.22
892	513	355	4344	161.70	0.00	0.00	77.51	21 20	0.00	0.00	239.21
892	517	355	4345	0.00	0.00	0.00	0.00		380.12	0.00	380.12
893	509	355	4343	0.00	0.00	0.00	0.00		8.16	0.00	8.16
893	511	355	4343	161.70	0.00	0.00	77.51	34	0.00	0.54	239.21
893	512	355	4344	0.00	0.00	0.00	0.00		23.44	0.54	23.44
893	513	355	4344	134.75	0.00	0.00	0.00		13.56	0.00	148.31
893	516	355	4345	0.00	0.00	0.00	0.00		91.79	0.00	91.79
893	517	355	4345	3.37	0.00	0.00	0.00		7.31	0.00	10.68
893	519	355	4346	23.58	0.00	0.00	0.00		135.61	0.00	159.19
894	509	356	4343	0.00	0.00	0.00	0.00		89.51	0.00	89.51
894	513	356	4344	407.61	0.00	0.00	77.51	20	15.11	0.00	500.24
894	516	356	4345	0.00	0.00	0.00	0.00		31.64	0.54	31.64
894	517	356	4345	0.00	0.00	0.00	0.00		1.80	0.00	1.80
894	518	356	4346	0.00	0.00	0.00	0.00		13.56	0.00	13.56
894	519	356	4346	3.37	0.00	0.00	77.51	21	0.00	0.00	80.88
895	508	356	4343	0.00	0.00	0.00	0.00		81.22	0.00	81.22
895	511	356	4343	80.85	0.00	0.00	0.00		0.00	0.00	80.85
895	516	356	4345	10.11	0.00	0.00	0.00		0.00	0.00	10.11
895	519	356	4346	0.00	0.00	0.00	0.00		11.30	0.00	11.30
896	506	356	4342	51.20	0.00	0.00	0.00		0.00	0.00	51.20
896	510	356	4343	0.00	0.00	76.09	0.00		0.00	0.00	76.09
896	511	356	4343	3.37	0.00	0.00	0.00		4.13	0.00	7.50
896	516	356	4345	0.00	0.00	0.00	0.00		12.43	0.00	12.43
896	517	356	4345	6.74	0.00	0.00	0.00		15.07	0.00	21.81
897	507	356	4342	0.00	0.00	797.12	0.00		0.00	0.00	797.12
897	511	356	4343	0.00	0.00	0.00	0.00		10.17	0.00	10.17
898	510	357	4343	0.00	0.00	0.00	0.00		20.72	0.00	20.72
898	514	357	4344	0.00	0.00	0.00	0.00		203.42	0.00	203.42
898	516	357	4345	0.00	0.00	0.00	0.00		1.03	0.00	1.03
899	512	357	4344	0.00	0.00	94.21	77.51	21	0.00	0.00	171.72
900	509	357	4343	67.37	0.00	0.00	0.00		8.64	0.00	76.01
900	510	357	4343	0.00	0.00	181.16	0.00		0.00	0.00	181.16
900	514	357	4344	3.37	0.00	0.00	0.00		0.00	0.00	3.37
900	516	357	4345	6.74	0.00	0.00	0.00		0.00	0.00	6.74
901	496	358	4339	0.00	0.00	0.00	0.00		1.68	0.00	1.68
901	497	358	4339	0.00	0.00	0.00	0.00		0.95	0.00	0.95
901	501	358	4340	20.21	0.00	108.70	0.00		0.00	0.00	128.91
901	509	358	4343	0.00	0.00	0.00	0.00		8.64	0.00	8.64

(continued)

TABLE 9. BALTIMORE AND ANNE ARUNDEL COUNTIES FUGITIVE DUST EMISSIONS BY SOURCE TYPE (continued)

MD. THOU. FT. X	MD. THOU. FT. Y	UTM THOU. MET. X	UTM THOU. MET. Y	GRAVEL ROADS LB/DAY	DIRT ROADS LB/DAY	CONSTR SITES LB/DAY	STORAGE PILES LB/DAY	STORAGE PILES TYPE	WIND EROSION LB/DAY	RAILROADS LB/VMT	TOTAL LB/DAY
901	512	358	4344	0.00	0.00	0.00	0.00		5.53	0.00	5.53
901	513	358	4344	0.00	0.00	0.00	0.00		1.41	0.00	1.41
901	514	358	4344	1.35	0.00	0.00	0.00		0.00	0.00	1.35
902	495	358	4339	0.00	0.00	0.00	0.00		35.43	0.00	35.43
902	496	358	4339	0.00	0.00	0.00	0.00		2.09	0.00	2.09
902	501	358	4340	478.36	0.00	0.00	0.00		0.00	0.00	478.36
902	508	358	4343	0.00	0.00	0.00	0.00		0.36	0.00	0.36
902	515	358	4345	53.90	0.00	0.00	0.00		0.00	0.00	53.90
903	508	358	4343	30.99	0.00	0.00	0.00		10.80	0.00	41.79
903	509	358	4343	0.00	0.00	0.00	0.00		25.38	0.00	25.38
903	514	358	4344	10.11	0.00	0.00	0.00		0.00	0.00	10.11
906	496	359	4339	0.00	0.00	0.00	0.00		510.24	0.00	510.24
906	504	359	4341	0.00	72.43	0.00	77.51	21	45.31	0.00	195.26
906	507	359	4342	0.00	0.00	0.00	0.00		53.99	0.00	53.99
906	508	359	4343	0.00	0.00	0.00	0.00		0.36	0.00	0.36
906	512	359	4344	0.00	0.00	0.00	0.00		20.72	0.00	20.72
906	513	359	4344	0.00	0.00	3170.37	77.51	20	0.00	0.00	3247.88
907	507	360	4342	804.45	0.00	0.00	0.00		0.00	0.00	804.45
908	482	360	4335	0.00	0.00	0.00	0.00		45.85	0.00	45.85
908	492	360	4338	0.00	0.00	0.00	0.00		0.90	0.00	0.90
908	494	360	4338	0.00	943.31	0.00	0.00		46.41	0.00	989.72
909	491	360	4337	0.00	0.00	0.00	0.00		3.31	0.00	3.31
909	505	360	4342	0.00	0.00	0.00	0.00		13.28	0.00	13.28
910	484	360	4335	0.00	0.00	0.00	0.00		5.05	0.00	5.05
910	493	360	4338	0.00	0.00	0.00	77.51	20	0.00	0.00	77.51
911	485	361	4336	4.04	0.00	0.00	77.51	21	0.00	0.00	81.55
911	493	361	4338	0.00	0.00	507.26	0.00		0.00	0.00	507.26
912	502	361	4341	3.37	0.00	0.00	0.00		0.00	0.00	3.37
913	474	361	4332	319.35	0.00	0.00	0.00		0.00	0.00	319.35
913	477	361	4333	57.94	0.00	0.00	0.00		16.83	0.00	74.77
913	482	361	4335	38.40	0.00	0.00	0.00		9.54	0.00	47.95
914	493	362	4338	0.00	0.00	0.00	77.51	36	0.00	0.00	77.51
914	497	362	4339	0.00	2.53	0.00	0.00		2.21	0.00	4.74
914	500	362	4340	0.00	0.00	0.00	0.00		14.75	0.00	14.75
915	479	362	4334	13.47	0.00	0.00	0.00		0.00	0.00	13.47
915	493	362	4338	0.00	0.00	0.00	77.51	39	0.00	0.00	77.51
								38			
								37			
916	488	362	4336	0.00	0.00	0.00	0.00		5.05	0.00	5.05
916	497	362	4339	0.00	0.00	0.00	77.51	36	0.00	0.00	77.51
917	474	363	4332	13.47	0.00	0.00	0.00		137.32	0.00	150.80
917	477	363	4333	0.00	0.00	0.00	0.00		8.85	0.00	8.85
917	479	363	4334	0.00	0.00	1811.64	77.51	21	0.00	0.00	1889.15
								20			
917	499	363	4340	0.00	1796.77	0.00	0.00		22.10	0.00	1818.87
918	474	363	4332	0.00	0.00	6.04	77.51	23	0.00	0.00	83.55
								22			

(continued)

TABLE 9. BALTIMORE AND ANNE ARUNDEL COUNTIES FUGITIVE DUST EMISSIONS BY SOURCE TYPE (continued)

MD. THOU. FT. X	MD. THOU. FT. Y	UTM THOU. MET. X	UTM THOU. MET. Y	GRAVEL ROADS LB/DAY	DIRT ROADS LB/DAY	CONSTR SITES LB/DAY	STORAGE PILES LB/DAY	STORAGE PILES TYPE	WIND EROSION LB/DAY	RAILROADS LB/VMT	TOTAL LB/DAY
918	497	363	4339	0.00	0.00	0.00	77.51	27	0.00	0.00	77.51
918	499	363	4340	0.00	197.65	0.00	77.51	23	15.47	0.00	290.63
								24			
919	475	363	4332	0.00	0.00	0.00	0.00		87.64	0.00	87.64
919	476	363	4333	0.00	10.11	0.00	77.51	22	8.81	0.00	96.42
919	497	363	4339	0.00	1006.19	0.00	0.00		13.26	0.00	1019.45
921	478	364	4333	0.00	0.00	0.00	0.00		12.95	0.00	12.95
921	498	364	4339	683.85	0.00	0.00	77.51	40	0.00	0.00	761.36
922	474	364	4332	0.00	0.00	0.00	0.00		0.95	0.00	0.95
922	480	364	4334	0.00	0.00	0.00	0.00		441.40	0.00	441.40
922	483	364	4335	0.00	0.00	52.66	77.51	21	0.00	0.00	130.17
								20			
923	483	364	4335	0.00	33.69	0.00	0.00		13.26	0.00	46.95
925	482	365	4335	0.00	0.00	0.00	77.51	24	1.57	0.00	79.09
926	475	365	4332	0.00	0.00	0.00	0.00		2.10	0.00	2.10
926	494	365	4338	0.00	0.00	239.14	0.00		0.00	0.00	239.14
927	481	366	4334	3.37	0.00	0.00	0.00		0.00	0.00	3.37
929	497	366	4339	0.00	0.00	0.00	0.00		0.00	0.00	0.00
930	479	367	4334	0.00	0.00	0.00	0.00		2.30	0.00	2.30
930	497	367	4339	7545.92	0.00	0.00	0.00		0.00	0.00	7545.92
931	478	367	4333	0.00	0.00	0.00	0.00		3.15	0.00	3.15
931	488	367	4336	25.60	0.00	0.00	77.51	24	0.00	0.00	103.11
931	494	367	4338	0.00	0.00	772.97	77.51	21	0.00	0.00	850.48
								20			
931	497	367	4339	0.00	0.00	0.00	77.51	21	0.00	0.00	77.51
								20			
932	473	367	4332	3.37	0.00	0.00	0.00		0.00	0.00	3.37
932	484	367	4335	0.00	0.00	0.00	77.51	24	0.79	0.00	78.30
933	437	367	4321	2155.98	0.00	0.00	0.00		0.00	0.00	2155.98
933	474	367	4332	0.00	0.00	0.00	0.00		1.73	0.00	1.73
933	518	367	4346	0.00	0.00	0.00	0.00		2.30	0.54	2.30
933	534	367	4350	0.00	0.00	0.00	0.00		22.90	0.00	22.90
933	537	367	4351	0.00	0.00	0.00	0.00		1.07	0.00	1.07
934	519	368	4346	0.00	0.00	0.00	0.00		4.32	0.00	4.32
934	523	368	4347	26.95	0.00	0.00	77.51	34	0.00	0.54	104.46
934	524	368	4347	0.00	0.00	0.00	0.00		0.00	0.54	0.00
934	534	368	4350	16.84	0.00	0.00	0.00		0.00	0.00	16.84
934	535	368	4351	47.16	0.00	0.00	0.00		8.85	0.00	56.01
934	572	368	4362	1212.74	0.00	0.00	77.51	21	129.92	0.00	1420.17
935	517	368	4345	67.37	0.00	0.00	0.00		0.00	0.00	67.37
935	518	368	4346	188.65	0.00	0.00	0.00		0.00	0.00	188.65
935	523	368	4347	269.50	0.00	0.00	0.00		0.00	0.54	269.50
935	524	368	4347	0.00	0.00	147.95	0.00		0.00	0.00	147.95
936	472	368	4332	0.00	0.00	0.00	0.00		1.91	0.00	1.91
936	484	368	4335	0.00	0.00	0.00	0.00		5.26	0.00	5.26
936	485	368	4336	3.37	0.00	0.00	0.00		0.00	0.00	3.37

(continued)

TABLE 9. BALTIMORE AND ANNE ARUNDEL COUNTIES FUGITIVE DUST EMISSIONS BY SOURCE TYPE (continued)

MD. THOU. FT. X	MD. THOU. FT. Y	UTM THOU. MET. X	UTM THOU. MET. Y	GRAVEL ROADS LB/DAY	DIRT ROADS LB/DAY	CONSTR SITES LB/DAY	STORAGE PILES LB/DAY	STORAGE PILES TYPE	WIND EROSION LB/DAY	RAILROADS LB/VMT	TOTAL LB/DAY
936	516	368	4345	0.00	0.00	0.00	0.00		3.86	0.00	3.86
936	519	368	4346	0.00	0.00	0.00	0.00		0.00	0.54	0.00
936	520	368	4346	0.00	0.00	0.00	0.00		2.88	0.00	2.88
936	522	368	4347	107.80	0.00	0.00	0.00		0.00	0.54	107.80
936	523	368	4347	26.95	0.00	0.00	0.00		0.00	0.00	26.95
936	525	368	4348	3.37	0.00	0.00	0.00		0.00	0.00	3.37
936	536	368	4351	6.74	0.00	0.00	0.00		7.20	0.00	13.94
936	537	368	4351	0.00	0.00	0.00	0.00		276.80	0.00	276.80
936	571	368	4362	0.00	0.00	0.00	0.00		24.30	0.54	24.30
937	485	369	4336	0.00	0.00	96.62	77.51	20	0.00	0.00	174.13
937	513	369	4344	53.90	0.00	0.00	77.51	21	0.00	0.00	131.41
937	514	369	4344	0.00	0.00	0.00	0.00		2.39	0.00	2.39
937	520	369	4346	0.00	269.52	0.00	0.00		6.63	0.00	276.15
937	525	369	4348	0.00	0.00	0.00	0.00		1.30	0.00	1.30
937	528	369	4349	0.00	0.00	0.00	0.00		12.15	0.00	12.15
937	543	369	4353	0.00	0.00	618.37	0.00		0.00	0.00	618.37
938	479	369	4334	0.00	0.00	0.00	0.00		0.72	0.00	0.72
938	487	369	4336	8.42	0.00	0.00	0.00		0.00	0.00	8.42
938	511	369	4343	1347.48	0.00	0.00	77.51	34	0.00	0.54	1425.00
938	512	369	4344	269.50	0.00	0.00	77.51	20	0.00	0.54	347.01
938	519	369	4346	0.00	0.00	0.00	0.00		3.24	0.00	3.24
938	520	369	4346	20.21	0.00	0.00	0.00		10.11	0.00	30.33
938	521	369	4346	0.00	0.00	603.88	77.51	21 20	0.00	0.00	681.39
938	522	369	4347	0.00	269.52	0.00	0.00		6.63	0.00	276.15
938	524	369	4347	0.00	16.84	0.00	0.00		3.31	0.00	20.16
938	525	369	4348	26.95	0.00	0.00	0.00		0.00	0.00	26.95
938	527	369	4348	0.00	0.00	0.00	0.00		74.58	0.00	74.58
938	530	369	4349	0.00	0.00	0.00	0.00		2.02	0.00	2.02
938	532	369	4350	0.00	0.00	0.00	0.00		2.58	0.00	2.58
938	542	369	4353	53.90	0.00	0.00	77.51	20	2.75	0.00	134.17
939	479	369	4334	0.00	0.00	0.00	0.00		0.60	0.00	0.60
939	485	369	4336	0.00	0.00	18.12	0.00		0.00	0.00	18.12
939	513	369	4344	107.80	0.00	0.00	0.00		2.59	0.00	110.39
939	514	369	4344	3.37	0.00	543.49	0.00		0.00	0.00	546.86
939	515	369	4345	26.95	0.00	0.00	0.00		0.00	0.00	26.95
939	518	369	4346	0.00	0.00	0.00	0.00		10.80	0.00	10.80
939	519	369	4346	0.00	0.00	0.00	0.00		17.53	0.00	17.53
939	522	369	4347	0.00	0.00	301.94	77.51	20	0.00	0.00	379.45
939	525	369	4348	0.00	0.00	0.00	0.00		4.52	0.00	4.52
939	537	369	4351	0.00	0.00	0.00	0.00		0.00	0.54	0.00
940	515	370	4345	33.69	0.00	0.00	0.00		3.24	0.00	36.93
940	517	370	4345	0.00	0.00	0.00	0.00		21.87	0.00	21.87
940	519	370	4346	0.00	0.00	0.00	0.00		0.00	0.54	0.00
940	525	370	4348	0.00	0.00	0.00	0.00		6.45	0.00	6.45
940	530	370	4349	10.11	0.00	0.00	0.00		0.00	0.00	10.11

(continued)

TABLE 9. BALTIMORE AND ANNE ARUNDEL COUNTIES FUGITIVE DUST EMISSIONS BY SOURCE TYPE (continued)

MD. THOU. FT. X	MD. THOU. FT. Y	UTM THOU. MET. X	UTM THOU. MET. Y	GRAVEL ROADS LB/DAY	DIRT ROADS LB/DAY	CONSTR SITES LB/DAY	STORAGE PILES LB/DAY	STORAGE PILES TYPE	WIND EROSION LB/DAY	RAILROADS LB/VMT	TOTAL LB/DAY
940	534	370	4350	0.00	0.00	0.00	0.00		44.11	0.00	44.11
940	538	370	4352	0.00	0.00	0.00	0.00		4.65	0.00	4.65
940	543	370	4353	0.00	0.00	0.00	77.51	20	8.85	0.00	86.36
941	475	370	4332	0.00	0.00	0.00	0.00		1174.05	0.00	1174.05
941	481	370	4334	0.00	0.00	0.00	0.00		1.63	0.00	1.63
941	511	370	4343	0.00	0.00	0.00	0.00		12.91	0.00	12.91
941	513	370	4344	0.00	0.00	362.33	77.51	21	0.00	0.00	439.84
941	517	370	4345	0.00	0.00	0.00	77.51	21	12.17	0.00	89.68
								20			
941	518	370	4346	0.00	0.00	0.00	0.00		0.00	0.54	0.00
941	520	370	4346	0.00	0.00	0.00	77.51	20	18.72	0.00	96.23
941	523	370	4347	0.00	0.00	0.00	0.00		17.64	0.00	17.64
941	524	370	4347	0.00	0.00	0.00	0.00		36.00	0.00	36.00
941	528	370	4349	0.00	0.00	0.00	0.00		28.80	0.00	28.80
941	529	370	4349	13.47	0.00	0.00	0.00		7.56	0.00	21.03
941	534	370	4350	13.47	0.00	0.00	0.00		0.00	0.00	13.47
941	543	370	4353	1886.48	0.00	0.00	0.00		0.00	0.00	1886.48
942	481	370	4334	269.50	0.00	0.00	0.00		0.00	0.00	269.50
942	514	370	4344	0.00	0.00	0.00	0.00		0.00	0.00	0.00
942	518	370	4346	0.00	0.00	0.00	77.51	20	0.00	0.54	77.51
942	519	370	4346	1243.73	4267.34	0.00	77.51	20	143.65	0.00	5732.23
942	521	370	4346	0.00	0.00	0.00	0.00		12.60	0.00	12.60
942	529	370	4349	51.20	0.00	0.00	0.00		8.30	0.00	59.50
942	533	370	4350	0.00	0.00	0.00	0.00		221.00	0.00	221.00
942	535	370	4351	0.00	0.00	0.00	77.51	21	0.00	0.00	77.51
								20			
942	538	370	4352	13.47	0.00	0.00	0.00		17.29	0.00	30.76
942	544	370	4353	13.47	0.00	0.00	0.00		9.42	0.54	22.89
943	480	370	4334	269.50	0.00	0.00	0.00		0.00	0.00	269.50
943	517	371	4345	33.69	0.00	0.00	0.00		0.00	0.00	33.69
943	528	371	4349	0.00	0.00	0.00	0.00		22.26	0.00	22.26
943	529	371	4349	269.50	0.00	0.00	0.00		0.00	0.00	269.50
943	535	371	4351	0.00	0.00	0.00	0.00		37.61	0.00	37.61
943	544	371	4353	10.11	0.00	0.00	0.00		12.81	0.00	22.91
943	545	371	4354	3.37	0.00	0.00	0.00		2.83	0.00	6.19
943	546	371	4354	0.00	0.00	0.00	0.00		11.30	0.00	11.30
944	517	371	4345	13.47	0.00	0.00	0.00		0.00	0.54	13.47
944	518	371	4346	0.00	0.00	0.00	0.00		24.90	0.00	24.90
944	520	371	4346	0.00	0.00	0.00	0.00		8.64	0.00	8.64
945	483	371	4335	0.00	0.00	12.08	77.51	24	0.00	0.00	89.59
945	529	371	4349	0.00	112.30	0.00	77.51	20	2.76	0.00	192.57
945	530	371	4349	26.95	0.00	0.00	0.00		0.00	0.00	26.95
945	544	371	4353	0.00	0.00	0.00	0.00		406.84	0.00	406.84
946	515	371	4345	0.00	0.00	0.00	0.00		1726.54	0.54	1726.54
946	521	371	4346	1.68	0.00	0.00	0.00		0.00	0.00	1.68
946	529	371	4349	67.37	0.00	0.00	77.51	41	0.95	0.00	145.84

(continued)

TABLE 9. BALTIMORE AND ANNE ARUNDEL COUNTIES FUGITIVE DUST EMISSIONS BY SOURCE TYPE (continued)

MD. THOU. FT. X	MD. THOU. FT. Y	UTM THOU. MET. X	UTM THOU. MET. Y	GRAVEL ROADS LB/DAY	DIRT ROADS LB/DAY	CONSTR SITES LB/DAY	STORAGE PILES LB/DAY	STORAGE PILES TYPE	WIND EROSION LB/DAY	RAILROADS LB/VMT	TOTAL LB/DAY
947	521	372	4346	10.11	0.00	0.00	0.00		0.00	0.00	10.11
947	525	372	4348	0.00	0.00	0.00	0.00		27.66	0.00	27.66
948	515	372	4345	3.37	0.00	0.00	0.00		0.00	0.00	3.37
948	524	372	4347	0.00	0.00	0.00	0.00		8.26	0.00	8.26
948	525	372	4348	0.00	0.00	0.00	0.00		36.89	0.00	36.89
948	526	372	4348	3.37	0.00	0.00	0.00		0.00	0.00	3.37
948	529	372	4349	0.00	0.00	6055.70	77.51	34	0.00	0.00	6133.21
949	523	372	4347	0.00	0.00	0.00	0.00		8.85	0.00	8.85
949	524	372	4347	13.47	0.00	0.00	0.00		0.00	0.00	13.47
949	525	372	4348	80.85	0.00	0.00	0.00		2.64	0.00	83.49
949	526	372	4348	538.99	0.00	0.00	0.00		0.00	0.00	538.99
950	520	373	4346	1.68	0.00	0.00	0.00		0.00	0.00	1.68
950	522	373	4347	3.37	21.06	0.00	0.00		4.14	0.00	28.57
950	523	373	4347	168.44	379.01	0.00	0.00		16.57	0.00	564.02
950	524	373	4347	2.02	63.17	0.00	0.00		21.32	0.00	86.51
950	525	373	4348	10.78	0.00	0.00	0.00		0.00	0.00	10.78
950	527	373	4348	161.70	673.79	0.00	0.00		16.57	0.00	852.06
950	528	373	4349	33.69	0.00	0.00	0.00		0.00	0.00	33.69
951	524	373	4347	0.00	0.00	0.00	0.00		51.80	0.00	51.80
952	510	373	4343	5.05	0.00	0.00	0.00		0.00	0.54	5.05
952	512	373	4344	0.00	0.00	0.00	0.00		0.00	0.00	0.00
952	515	373	4345	0.00	0.00	0.00	0.00		0.00	0.54	0.00
952	516	373	4345	619.84	0.00	0.00	77.51	21	0.00	0.00	697.36
952	518	373	4346	323.40	0.00	0.00	0.00		0.00	0.00	323.40
952	520	373	4346	20.21	0.00	0.00	0.00		0.00	0.00	20.21
952	521	373	4346	13.47	0.00	0.00	0.00		0.00	0.00	13.47
952	523	373	4347	128.68	0.00	0.00	0.00		0.00	0.00	128.68
952	526	373	4348	134.75	0.00	0.00	0.00		0.00	0.00	134.75
953	505	374	4342	0.00	0.00	0.00	0.00		0.46	0.00	0.46
953	510	374	4343	10.11	21.06	0.00	0.00		4.82	0.54	35.98
953	512	374	4344	296.45	0.00	0.00	0.00		0.00	0.00	296.45
953	517	374	4345	10.11	0.00	0.00	0.00		0.00	0.00	10.11
953	526	374	4348	175.17	729.94	0.00	0.00		71.82	0.00	976.94
954	505	374	4342	0.00	0.00	0.00	0.00		0.24	0.00	0.24
954	510	374	4343	8.42	0.00	0.00	0.00		0.00	0.00	8.42
954	511	374	4343	0.00	0.00	0.00	77.51	34	6.44	0.00	83.95
954	520	374	4346	0.00	0.00	0.00	0.00		0.00	0.54	0.00
954	522	374	4347	0.00	0.00	0.00	0.00		30.78	0.00	30.78
954	524	374	4347	0.00	0.00	0.00	0.00		324.59	0.00	324.59
954	525	374	4348	40.42	0.00	0.00	0.00		0.00	0.00	40.42
955	505	374	4342	0.00	0.00	0.00	0.00		0.72	0.00	0.72
955	510	374	4343	28.63	0.00	0.00	0.00		0.00	0.00	28.63
955	511	374	4343	26.95	0.00	157.01	0.00		0.00	0.00	183.96
955	514	374	4344	26.95	0.00	0.00	0.00		0.00	0.00	26.95
955	517	374	4345	0.00	0.00	0.00	77.51	21	119.06	0.00	196.57
955	518	374	4346	3.37	0.00	0.00	0.00		0.00	0.00	3.37

(continued)

TABLE 9. BALTIMORE AND ANNE ARUNDEL COUNTIES FUGITIVE DUST EMISSIONS BY SOURCE TYPE (continued)

MD. THOU. FT. X	MD. THOU. FT. Y	UTM THOU. MET. X	UTM THOU. MET. Y	GRAVEL ROADS LB/DAY	DIRT ROADS LB/DAY	CONSTR SITES LB/DAY	STORAGE PILES LB/DAY	STORAGE PILES TYPE	WIND EROSION LB/DAY	RAILROADS LB/VMT	TOTAL LB/DAY
955	520	374	4346	3.37	0.00	0.00	0.00		0.00	0.00	3.37
956	508	374	4343	0.00	0.00	507.26	0.00		0.00	0.00	507.26
956	510	374	4343	0.00	0.00	0.00	0.00		3.64	0.00	3.64
956	512	374	4344	3.37	0.00	0.00	0.00		0.00	0.00	3.37
957	501	375	4340	3.37	0.00	0.00	0.00		0.00	0.00	3.37
957	506	375	4342	0.00	0.00	0.00	0.00		8.85	0.00	8.85
957	511	375	4343	13.47	0.00	0.00	0.00		0.00	0.00	13.47
957	512	375	4344	6.74	0.00	0.00	0.00		0.00	0.00	6.74
958	510	375	4343	0.00	0.00	0.00	0.00		7.40	0.00	7.40
958	511	375	4343	60.64	0.00	0.00	0.00		0.00	0.00	60.64
958	512	375	4344	3.37	0.00	0.00	0.00		0.00	0.00	3.37
958	513	375	4344	272.87	0.00	0.00	0.00		0.00	0.00	272.87
959	513	375	4344	0.00	0.00	0.00	0.00		51.80	0.00	51.80
960	509	376	4343	0.00	0.00	0.00	0.00		161.98	0.00	161.98
961	509	376	4343	3.03	0.00	0.00	0.00		0.00	0.00	3.03
962	509	376	4343	0.00	0.00	0.00	0.00		72.89	0.00	72.89
969	510	378	4343	10.11	0.00	0.00	0.00		0.00	0.00	10.11
969	511	378	4343	0.00	0.00	0.00	0.00		0.18	0.00	0.18
970	512	379	4344	6.74	0.00	0.00	0.00		0.00	0.00	6.74
TOTAL				24847.96	10886.21	17307.30	3798.11		8731.76		65571.32

(continued)

TABLE 9. BALTIMORE AND ANNE ARUNDEL COUNTIES FUGITIVE DUST EMISSIONS BY SOURCE (concluded)

TYPE OF MATERIAL IN STORAGE PILES

20 FINE MATERIAL
21 COARSE MATERIAL
22 DIRT
23 GRAVEL
24 SAND
25 COAL
26 OYSTER DUST
27 MANGANESE ORE
28 IRON ORE
29 TRASH
30 ORE PILES
31 CONCRETE
32 STONE
33 METAL
34 UNKNOWN
35 ROAD SALT
36 CHROME ORE
37 FERROCHROME ORE
38 FERROMANGANESE ORE
39 BATTERYMANGANESE ORE
40 SANDBLASTING GRIT
41 CINDER BLOCKS

THE X AND Y CO-ORDINATES ARE FOR A COMBINATION OF LOTS THAT HAVE THE SAME CO-ORDINATES, IN ANNE ARUNDEL AND BALTIMORE COUNTIES, JUST SOUTH OF BALTIMORE CITY. THE CO-ORDINATES ARE ROUGHLY FOR THE CENTER OF THE LOT.

BECAUSE OF THE LACK OF DETAILED PAVED ROAD VMT FOR ANNE ARUNDEL AND BALTIMORE COUNTIES AND BECAUSE THE PAVED ROAD EMISSIONS ARE GENERALLY NEGLIGIBLE, THEY ARE NOT INCLUDED.

THE RAILROAD EMISSIONS ARE BASED ON 1/10 OF THE EMISSIONS PRODUCED BY THE GRAVEL ROAD EQUATION. BECAUSE NO RAILROAD VMT ARE AVAILABLE, JUST THE APPROPRIATE EMISSION FACTOR IS PRINTED.

ALL FUGITIVE EMISSION EQUATIONS ARE FOR PARTICLES WITH AN AERODYNAMIC DIAMETER <30 MICRONS.

A THROUGHPUT RATE OF 100,000 TONS/YEAR IS ASSUMED FOR STOCKPILES.

THE DIRT AND GRAVEL ROAD VMT ARE CALCULATED TO INCLUDE DIRT AND GRAVEL PARKING LOTS, AND ARE BASED ON THE BAQNC SURVEY INFORMATION. ALL OTHER INPUT INFORMATION EXCEPT SOIL SILT CONTENTS AND ERODIBILITIES WAS FURNISHED BY THE BAQNC SURVEY.

TABLE 10a. FUGITIVE PARTICULATE EMISSIONS FOR 1977 MARYLAND INVENTORY BALTIMORE COUNTY AND BALTIMORE CITY MAJOR POINT SOURCES

Company	SIC	Equipment Type: State Code	Equipment Type: Description	Particulate Emission Type of Material	Density[1] (gm/cm³)	Diameters of Emitted Material (μm)	Fugitive Emission Factor[2]	RR*
U.S. Gypsum Co.	3275	701	belt conveyor	gypsum	2.32	10-20% by wt <5	0.24 lb/ton cement unloaded p. 2-314	D
Dreyfus, Louis Corp.	5153	450	tray direct dryer	grain	sp. gr. 1	10-100	0.19-8 lb/ton dried p. 2-263	D
Indiana Grain	2041	700	general convey area	flour, grain	sp. gr. 1	10-100	1-2.5 lb/ton conveyed p. 2-263	D
Campbell Grove Texas	3273	650	crushers	limestone, clay, sand iron ore	limestone 2.7, clay 2, sand 2, iron ore sp. gr. 4	none available	0.5 lb/ton crushed p. 2-283	C
Bethlehem Steel Corp.	3312	932	scrap-open hearth	iron oxide	sp. gr. 5.18	mean diameter 0.3-5 50-99% <5	0.1-0.39 lb/ton steel p. 2-89	D
Bethlehem Steel Corp.	3312	901	iron-blast furnace	iron oxides, coke, sinter, slag, molten pig iron	sp. gr. 5.18	15-90% particulates emitted have mean diameter <70	blast furnace upsets (slips) 0.0038-0.038 lb/ton iron produced	E
							blast furnace tapping - iron 0.3-0.92 lb/ton iron produced p. 2-74	E
Bethlehem Steel Corp.	3312	263	coke oven	coal, coke dust, hydro-carbons, organic compounds	1.5	For emissions captured by a hood, (large particles are captured) 11% <10, 4% <2	coal charging 1-10 lb/ton coal charged p. 2-55	C
							coking (door leakage) 0.4-0.9 lb/ton coal charged p. 2-55	C
						For pushing emissions captured by a shed (large particles not captured) 27-80% <10, 15-26% <2	for pushing fugitive emission factors see p. 2-56	None
Bethlehem Steel Corp.	3312	929	steel - B.O.F.	iron oxide	sp. gr. 5.18	mean = 0.5 85-99% <5	0.15-1.2 lb/ton steel p. 2-89	D
Bethlehem Steel Corp.	3312	700, 701	general convey area, belt conveyor	iron ore, limestone, coke, coal, blast furnace, flue dust, sinter, slag	iron ore sp. gr. 4	none available	iron ore handling and transfer 2 lb/ton ore handled p. 2-73	D
					limestone 2.7	mean diameter 3-6 45-70% <5	limestone handling and transfer 0.2 lb/ton limestone handled p. 2-73	E

NOTE: The fugitive emission factors should be used only after reviewing the footnotes on their development and applicability contained in the PEDCo report.

* Reliability rating: C - Supportable by multiple test data; D - Supportable by limited test data and engineering judgment; E - Supportable by best engineering judgment (visual observation, emission tests for similar sources, etc.).

1 CRC Handbook of Chemistry and Physics, 53rd Edition. 1972-1973.

2 Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. PEDCo, March 1977.

TABLE 10b. FUGITIVE PARTICULATE EMISSIONS FOR 1977 MARYLAND INVENTORY
BALTIMORE COUNTY AND BALTIMORE CITY MAJOR POINT SOURCES

Company	SIC	Equipment Type State Code	Equipment Type Description	Particulate Emission Type of Material	Density[1] (gm/cm^3)	Diameters of Emitted Material (μm)	Fugitive Emission Factor[2]	RR*
Bethlehem Steel Corp. (contd)					coke 1.5	mean diameter 3-10	coke handling 0.023-0.13 lb/ton coke produced p. 2-55	E
					coal 1.5	mean diameter 1-10	coal conveying and transfer 0.04-0.96 lb/ton coal charged p. 2-54	E
					blast furnace dust no information	none available	blast furnace flue dust handling and transfer 0.3 lb/ton flue dust p. 2-73	E
					sinter sp. gr. 4	mean diameter 48-180 80% <100	sinter handling and transfer 0.4 lb/ton sinter p. 2-74	E
					slag 3	none available	slag handling 0.02-0.1 lb/ton slag p. 2-74	C
Bethlehem Steel Corp.	3312	226	sintering machines	ore dusts, metal oxides	sp. gr. 4	mean diameter 48-180 1-10% <5	0.55-2.45 lb/ton sinter p. 2-73	E
				iron oxides	sp. gr. 5.18	mean diameter 48-180 80% <100	sinter cooler 0.32-0.8 lb/ton sinter p. 2-73	E
Taylor-Middlecreek	3295	650	crushers	soft ores, earth materials	generally 2.8	<100	primary crushing 0.5lb/ton ore p. 2-241	E
							transfer and conveying 1.5 lb/ton ore p. 2-241	E
							secondary crushing/screening 0.044-1.5 lb/ton ore p. 2-241	E

NOTE: The fugitive emission factors should be used only after reviewing the footnotes on their development and applicability contained in the PEDCo report.

* Reliability rating: C - Supportable by multiple test data; D - Supportable by limited test data and engineering judgment; E - Supportable by best engineering judgment (visual observation, emission tests for similar sources, etc.).

1 CRC Handbook of Chemistry and Physics, 53rd Edition. 1972-1973.

2 Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions, PEDCo, March 1977.

expected to be smaller in comparison to these sources and the emissions coded for area sources. Sources with fugitive emissions were identified by listing the Standard Industrial Classification (SIC) and equipment type used to characterize the 140 largest sources in the state inventory for the MBIAQCR. From this information, those sources which correspond to types of operations for which fugitive emissions have been defined were selected. The type of material emitted, the density and size of emitted particles and appropriate emission factors are listed in Table 10. The available Maryland emission inventory does not include process rates, so actual emission estimates are not included. The emission data are taken from a report by PEDCo Environmental, Incorporated (1977); references to specific pages in this volume are included for convenience.

SECTION 5

ANALYSIS OF HI-VOL SAMPLES

Hi-vol filters collected at three sites in the TSP non-attainment area over a period of 7 months were reviewed to select 18 filters for microscopy and chemical analyses. The selection of sampling sites and specific filters was made by personnel at the Maryland BAQNC. The selected filters represent days with different prevalent wind directions and speeds and different particulate loadings. On three days filters from all three sites were selected for analysis. Table 11 identifies the dates and day of the week on which hi-vol filters were exposed at the three selected sites during the period from June to December 1977 and shows the TSP concentrations measured by each filter. The procedure for collecting data and determining the measured concentration is described in Appendix A.

For the selected filters, the weights of the filter before and after exposure, the amount of rain which occurred on the day the sample was collected and the preceding day, and the 24-hour mean wind speed on the sampling day are shown in Table 11. Of the nine days on which the 18 selected filters were collected, one day had more than 0.01 inches of rain and three other days had more than 0.01 inches of rain the day before. The mean wind speed varied from 0.9 to 2.9 m/sec (2.0 to 6.5 mph) among the 9 days, compared to the climatological mean wind speed for Baltimore of 4.6 m/sec (10.4 mph). Therefore, the samples represent lighter than normal wind speed situations.

The selected filters were analyzed by IITRI using microscopy, chemical analysis and supporting chemical and physical analyses selected by the microscopist. The findings regarding the principal types of particles on each analyzed filter are summarized in Table 12. It was found that the following six types of particulate materials made up from 65 to 93 percent of the TSP matter analyzed on each filter:

Silicates
Sulfates
Rubber
Calcite
Cornstarch
Slag.

The results presented in Table 12 do not include estimates of less than 10 percent. The above categorization is based on a combination of chemical tests of filter materials and microscopy analysis of removed particles.

Table 11. HIGH-VOLUME SAMPLER DATA

DATE DAY OF WEEK	CONCENTRATION ug/m³ Ft. McH	FD #10	FD #22	Initial Wt., gms	Final Wt., gms	Rain Day of Sample (inches)	Rain Day Before Sample (inches)	Daily Ave. Wind Speed (miles per h)
6/9/77 Th	(59*)	(63)	—	Ft. McH.-3.9931 FD #10-4.2498	4.1010 4.4137	1.36	0	6.2
6/15/77 W	129	205	196					
6/21/77 T	136	145	(60)	3.9510	4.0692	0	0.26	6.3
6/27/77 M	90	—	114					
7/3/77 Su	—	—	62					
7/9/77 Sa	35	106	83					
7/15/77 F	114	(221)	(149)	FD #10-4.2624 FD #22-3.9819	4.8402 4.2763	0	0	2.0
7/21/77 Th	141	219	102					
7/27/77 W	103	112	63					
8/2/77 T	(154) X	142	93	3.9536	4.2650	0	0.03	2.8
8/8/77 M	103	139	38					
8/14/77 Su	92	—	—					
8/20/77 Sa	75	72	67					
8/26/77 F	89	156	91					
9/1/77 Th	96	114	101					
9/7/77 W	—	—	59					
9/13/77 T	64	113	92					
9/19/77 M	69	165	(108)	3.9939	4.1994	0	0	3.5
9/25/77 Su**	(39)	(51)	(38) X	Ft. McH.-3.8745 FD #10-4.1485 FD #22-3.9477	3.9504 4.2395 4.0252	Trace	Trace	6.5
10/1/77 Sa	49	102	61					
10/7/77 F	59	87	55					
10/13/77 Th	47	63	42					
10/19/77 W	79	112	35					
10/25/77 Tu	(118)	(306) X	Lost	Ft. McH.-3.8911 FD #10-4.0672	4.1360 4.9129	0	0	3.2
10/31/77 M	56	96	60					
11/6/77 Su	25	21	24					
11/12/77 Sa	63	52	260					
11/18/77 F	101	90	94					
11/24/77 Th	(41)	(42)	(52)	Ft. McH.-4.1411 FD #10-4.1741 FD #22-3.8202	4.2194 4.3006 3.9240	0.01	0.31	4.3
11/30/77 W	50	—	41					
12/6/77 Tu	90	65	59					
12/12/77 M	(85)	(169)	(129)	Ft. McH.-4.3434 FD #10-4.1621 FD #22-3.9429	4.5191 4.6606 4.1059	Trace	0	4.6
12/18/77 S	75 Blank***	33	79 Black					

* Circled values are filters used in analysis.

** A fourth filter for 9/25/77 was obtained from the Northwest Police Station. Concentration: 34 ug/m³; initial wt.: 3.9984 gms; final wt.: 4.0973 gms.

X Indicates filters selected for duplicate analysis.

***Three blank filters were sent to GEOMET, one from Ft. McHenry and two from FD #22.

Rainfall is from Baltimore-Washington International Airport.

Wind speeds are from State-operated tower at Sun and Chesapeake Streets in Baltimore except 11/24/77, which is from Baltimore-Washington International Airport.

TABLE 12. PREDOMINANT MATERIALS FOUND ON HI-VOL FILTERS

Station	6/9/77	6/21	7/15	8/2	9/19	9/25	10/25	11/24	12/12
FD #10	Si 41%		Si 40%			Su 36%	Sl 31%	Su 35%	Ca 40%
	Su 21		Ca 30			Si 35	Ca 25	Si 32	Si 30
	Ru 12		Su 13			Ru 11	Si 17	Ru 11	Su 13
	Ca 13		Ru 7			Ca 10	Su 13	Total 78	Ru 8
	Total 87		Total 90			Total 92	Total 96		Total 91
Ft. McHenry	Si 44%			Co 41%		Su 50%	Si 44%	Su 45%	Si 33%
	Su 30			Si 23		Si 24	Su 18	Si 32	Su 25
	Co 11			Su 15		Total 74	Co 8	Ru 14	Ru 12
	Total 85			Total 79			Total 70	Total 91	Ca 14
									Total 84
FD #22		Si 52%	Si 54%		Si 45%	Su 40%		Si 35%	Si 37%
		Su 24	Su 16		Su 22	Si 37		Su 32	Su 17
		Ru 14	Ru 9		Ru 11	Ru 12		Ru 24	Ca 14
		Total 90	Total 79		Total 78	Total 89		Total 91	Ru 10
									Total 78

Note: Si = silicates
Su = sulfates
Ru = rubber
Ca = calcite
Co = cornstarch
Sl = slag

Includes all material with % by weight ≥ 10 only.

The microscopist categorizes individual particles into component types by optically viewing particles while testing various optical and physical properties such as listed in Table 13. In this study 18 different component types were identified. The weight percentage (of the total weight of particles analyzed) of each component type on each filter as identified by the microscopist is listed in Appendix E. These component types are further distinguished as six particle types which have source oriented characteristics. The following six source type particles were identified:

Minerals
Mobile source emissions
Large combustion source emissions
Nonspecific combustion source emissions
Industrial emissions
Biologicals.

The microscopist's notes on how the particle classifications were determined are given in Appendix E. The percentage of the mass on each analyzed filter attributed to each of the above six source types by the microscopist is listed in Table 14. Also shown in Table 14 is the percentage of the filter sample which is removed by low temperature plasma ashing. This information is a further guide to the microscopist as to how to interpret his particle classifications in terms of sources.

TABLE 13. MICROSCOPICAL PROPERTIES OF PARTICLES

Optical	Physical
Transparency	Size
Color	Shape
Refractive index	Solubility
Pleochroism	Density
Birefringence	Surface texture
Reflectance	Magnetism
Fluorescence	Melting point

TABLE 14. SUMMARY OF PARTICLES CLASSIFIED BY SOURCE TYPE BY MICROSCOPY

Date	Site	TSP Concentration ($\mu g/m^3$)	Low Temperature Ashing (% Removed)	Minerals %	Mobile Emissions %	Combustion Sources %	Non-Specific Combustion %	Corn Starch %	Biologicals %
6/9/77	FD #10	63	41%	57	13	3	23	2	2
	Ft. Mc	59	51%	49	3	4	31	12	<0.5
6/21/77	FD #22	60	44%	54	15	3	24	1	4
7/15/77	FD #10	221	29%	71	8	4	16	1	1
	FD #22	149	40%	58	10	7	20	4	1
8/2/77	Ft. Mc	154	65%	30	5	2	16	43	1
9/19/77	FD #22	108	42%	56	12	6	24	3	1
9/25/77	FD #10	51	39%	46	12	5	36	<0.5	<0.5
	FD #22	38	50%	39	13	5	40	2	2
	Ft. Mc	39	51%	29	7	10	50	2	1
10/25/77	FD #10	306	23%	44	4	4	16	31	<0.5
	Ft. Mc	118	48%	50	8	9	23	9	<0.5
11/24/77	FD #10	42	45%	40	13	8	37	3	<0.5
	FD #22	52	47%	40	26	3	33	<0.5	<0.5
	Ft. Mc	41	60%	35	16	4	47	1	<0.5
12/12/77	FD #10	169	31%	70	9	2	19	1	<0.5
	FD #22	129	40%	56	11	4	22	3	<0.5
	Ft. Mc	85	51%	48	13	7	28	5	<0.5

Duplicate microscopical analysis was performed on 3 of the 18 analyzed filter halves. One-half inch was trimmed off the straight edge of each of the three filter halves to prevent identification of the duplicate filters by matching the cut edges. This did not prevent filter identification, however, as the filter color and particle characteristics were sufficient to enable the microscopist to identify the particular filters. The normalized results of the duplicate analyses closely agreed with the corresponding original normalized results as indicated in Table 15. The ratio of the mean difference between pairs of filters to the average weight percentage is shown for each component particulate type. The ratios vary from zero to 0.85. The mean ratio is 0.25. Because the particulate matter collected on a filter have color and texture characteristics which vary from day to day, it is not difficult for a microscopist to match an unidentified filter to one of 18. A much larger number of filters is required where individual filters are not so easily distinguishable to get a better test of the repeatability of the microscopy analysis. It may be noted that there are very small differences between paired filter halves for particles which compose more than 20 percent of the total mass. The larger percentage of particles of a given type on a filter, the higher the probability that the sample of particles selected for microscopy will produce the same mass percentage estimate. When the percentage is small, the samples selected from the sample filter are more likely to produce different mass estimates because a difference of one or two particles in the selected sample will greatly change the mass estimate which is derived. The results in Table 15 show that very consistent estimates occur for particles which made up high mass percentages of the collected material. On this basis, it is concluded that the types of particles which have high contributions are accurately assessed.

In reviewing the results of the chemical and microscopy analysis, it is evident that soil is a probable source of the high silicate concentrations. Vehicular traffic and wind-generated dust from surrounding bare soil-covered areas are likely airborne silicate contributors.

The recrystallized sulfates probably represent the background sulfate level because as the total sampled mass concentration increases, the percent by weight of sulfates decreases, and as the total mass concentration decreases, the percent by weight of sulfate increases; in other words, the sulfate concentration tends to be less variable than the TSP.

The high concentrations of rubber tire fragments are probably generated by vehicular travel, and carried by the wind.

Possible sources of the high calcite concentrations are gravel and concrete road surfaces. Vehicular travel and wind erosion would generate the airborne calcite particulate.

TABLE 15. RESULTS OF DUPLICATE MICROSCOPY ANALYSIS

Component	% by Weight						Mean Difference Divided by Mean
	Set 1		Set 2		Set 3*		
	1st	2nd	1st	2nd	1st	2nd	
Silicates	23	23	47	47			0 (2)**
Calcite	5	13	1	2			0.85 (2)
Mica	<0.5	<0.5	< 0.5	<0.5	< 0.5		0 (2)
Clays, humus	2	1	1	1	2		0.4 (2)
Hemolite	2	1	1	0.5			0.67 (2)
Carbonaceous tailpipe exhaust	0.5	0.5	1	1	1	1	0
Rubber tire fragments	5	2	4	4	3		0.4 (2)
Glassy flyash	1	0.5	1	2			0.43 (2)
Coal fragments	0.5	0.5	1	0.4			0.25 (2)
Oil soot	1	1	2	3	1	1	0.22
Fine carbonaceous particles	1	1	< 0.5	< 0.5	2		0 (2)
Recrystallized sulfates	15	9	40	38	13	12.6	0.13
Cornstarch	41	46	< 0.5	< 0.5	<0.5	<0.5	0.11
Pollens, spores, conidia	<0.5	1	1	2	<0.5	<0.5	0.37
Plant parts	<0.5	<0.5	< 0.5	< 0.5	<0.5	<0.5	0
Insect parts	1	<0.5	1	< 0.5	<0.5	<0.5	0.5
Magnetic fragments	<0.5	<0.5	< 0.5	< 0.5	<0.5	<0.5	0
Total	98.0+	99.5+	101.0+	100.9+			0.25 (mean)

*Results are incomplete for this comparison.

**A two in parentheses (2) indicates result is based on two comparisons.

The high cornstarch concentrations are found only at the Fort McHenry station on the days June 9, 1977, August 2, 1977, and October 25, 1977. The source of the airborne cornstarch is probably nearby loading and unloading harbor operations. Table 16 indicates that in the first half of 1977, 2,025 thousand tons of corn were exported through the Baltimore Harbor area. In 1976 a total of 3,992 thousand tons were exported. This is one of the largest materials handled by the harbor.

October 25, 1977, at Fire Department #10 Station, high concentrations of slag were found. The likely source of this material is the Bethlehem Steel plant.

The results in Table 14 show that mineral plus mobile emissions constitute from 35 to 79 percent of the samples analyzed. On the average we estimate that fugitive emissions from the seven sources identified in our fugitive emission inventory constitute about 50 percent of the TSP concentrations measured by the hi-vols. This estimate provides a basis for determining the importance of fugitive emission control strategies. A further analysis of the importance of various point sources in contributing to the concentrations measured by each filter can be deduced by modeling the impact of point sources. Appendix F illustrates which of the 132 major point sources in the Maryland BAQNC inventory are upwind of each of the three monitoring sites for each 22.5° upwind sector. Also shown in Appendix F is the percentage of time and the average speed that the wind blew from each sector on each sampling day for which a filter was analyzed in this study. An analysis of the possible impact of point sources on the analyzed samples has not been considered in this study. Nor has an attempt been made to determine the extent to which the supplemented emission inventory which was derived will account for actual measured TSP concentrations. A detailed modeling study to develop such comparisons is a reasonable extension of the present study.

A preliminary analysis was to try to identify whether a few key point sources would account for major contributions to the measured TSP concentrations. However, the wind direction was generally quite variable. The mean wind speed and the range of variations in hourly wind speeds from this mean are listed in Table 17 for the nine sampling days. The variations in wind direction are large and the job of analyzing the contribution of individual sources was judged to be beyond the scope and resources of this study. A more detailed listing of hourly wind direction variations is given in Appendix G.

TABLE 16. BALTIMORE HARBOR MATERIAL THROUGHPUT FOR 1976 and 1977 (10^3 SHORT TONS)*

Material	1976 Import	1976 Export	1977 (Jan to Jun) Import	1977 (Jan to Jun) Export
Coal		6,536		3,185
Corn		3,992		2,025
Wheat		905		50
Barley		30		5
Soybeans		857		421
Soybean Meal		207		60
Fertilizers	45	37	101	3
Coke, Pitch & Asphalt		10		6
Iron Ore	10,308		2,736	
Manganese Ore	371		131	
Miscellaneous Ores	183		135	
Petroleum and Petroleum Products	4,297		2,757	
Sugar	544		239	
Molasses	161		74	
Salt	240		256	
Gypsum	685		254	
Bauxite	174		60	

* Source: Mr. William Walsek, Department of Marketing Statistics, Maryland Port Administration, World Trade Center, Baltimore, Maryland.

TABLE 17. RESULTANT 24-HOUR WIND DIRECTION AND THE RANGE OF HOURLY VARIATIONS FROM THE RESULTANT WIND

Date (1977)	24-Hour Resultant Wind Direction	Range of Hourly Variations from Resultant Wind
Jun 9	224	-91 to 156
Jun 21	270	-45 to 22
Jul 15	144	-104 to 144
Aug 2	247	-68 to 134
Sep 19	229	-86 to 116
Sep 25	57	-33 to 34
Oct 25	119	-151 to 119
Nov 24	291	-69 to 88
Dec 12	199	-161 to 42

SECTION 6

FUGITIVE EMISSION CONTROL STRATEGIES

Our literature search has indicated suitable control strategies and, when possible, their effectiveness for all the fugitive particulate source categories. The following control strategies listed by source type are ranked with greatest reduction first, and least reduction, last.

GRAVEL AND DIRT ROADS

1. Paving the unpaved roads will reduce dust emissions by 85 percent (PEDCo 1977).

2. Regularly applying water to the surface of unpaved roads or applying a chemical stabilizer will reduce emissions by 50 percent. Oiling and double chip surface will reduce emissions by 85 percent (PEDCo 1977).

3. Low vehicle speeds will minimize dust emissions. The total dust emissions from unpaved roads increases in proportion to the average vehicle speed.

4. Stabilizing road shoulders will reduce shoulder emissions by 80 percent (PEDCo 1977).

5. Vehicles traveling on unpaved roads generate dust in proportion to their number of wheels. Decrease multi-wheeled truck activity on unpaved roads (Cowherd et al. 1974).

CONSTRUCTION SITES AND WASTE DISPOSAL SITES

Construction

1. Regularly applying water to exposed soil is an effective means of dust control (Cowherd et al. 1974).

2. Construction activity levels influence emission rates from the sites significantly. However, this emission rate variation has not been quantified (Cowherd et al. 1974).

Waste

1. Emissions due to handing can be reduced by over 99 percent by keeping the handled materials wet. Covered or enclosed hauling and minimizing the free fall of material can also reduce emissions (PEDCo 1977).

2. Revegetation of waste disposal sites can reduce emissions by 25 to 100 percent (Jutze and Axetell 1974).

3. Dumping emissions can be reduced by 50 percent by using spray bars at dump areas. Minimizing the free fall of material and using semi-enclosed bins can also reduce emissions (PEDCo 1977).

4. Emissions due to grading operations can be reduced 50 percent by watering (PEDCo 1977).

STORAGE PILES

1. Emissions from the movement of storage piles can be reduced by 95 to 99 percent by enclosing the pile (PEDCo 1977).

2. Emissions from loading onto piles can be reduced 70 to 99 percent by enclosing piles (Cross and Forehand 1975).

3. Adjustable chutes can reduce emissions by 75 percent (PEDCo 1977).

4. Chemical wetting agents or foam can reduce emissions by 50 to 90 percent (Jutze and Axetell 1974, Evans 1975).

5. Wind erosion emissions from storage piles can be reduced by 95 to 99 percent by enclosing the piles. Wind screens are inefficient at reducing emissions. Chemical wetting agents or foam can reduce emissions by 90 percent (PEDCo 1977).

6. Emissions due to loadout operations can be reduced by 50 percent by water spraying. Gravity feed onto conveyor can reduce emissions by 80 percent. Use of a stacker/reclaimer can reduce loadout emissions by 25 to 50 percent (Cowherd et al. 1977).

WIND EROSION

1. Reduction of surface wind speed across a source is a logical means of reducing emissions. This takes such forms as windbreaks, enclosures or coverings for the sources, and planting of tall grasses or grains on or adjacent to exposed surfaces (PEDCo 1977).

2. Frequently used materials for physical stabilization of fine tailings are rock and soil obtained from areas adjacent to the surface to be covered. Soil provides an effective cover and a medium for vegetation growth. However, the soil must support vegetation growth and therefore must contain nutrients, moisture, proper texture and no phytotoxicants. Vegetation cover can reduce emissions by 65 percent (PEDCo 1977).

3. Crushed or granulated smelter slag, a waste product, has been used to stabilize tailings, and can reduce emissions by 90 to 99 percent (U.S. EPA 1976).

4. Another method is to cover tailings or exposed surfaces with bark or harrowing straw into the top few inches of material (PEDCo 1977).

5. Watering exposed surfaces by using sprinklers or trucks can reduce emissions by 50 percent (U.S. EPA 1976).

6. Chemical stabilization of exposed surfaces can reduce emissions by 80 percent (Engr. Mining J. 1971).

7. A combination of chemical and vegetative stabilization can result in 90 percent reduction of emissions (U.S. EPA 1976).

RAILROADS

1. Cover the open-top railroad cars so that contained aggregates will not be picked up by the wind.

2. Oiling the shoulders of the tracks will reduce emissions generated by turbulence created by train passage.

PAVED ROADS

1. Keep roads in good repair. Streets in bad repair have dust loadings about twice as high as streets in good repair (Cowherd et al. 1977).

2. Use concrete surfaces rather than asphalt. Reentrained dust from asphalt streets is about 80 percent higher than concrete streets (Cowherd et al. 1977).

3. Regular street cleaning may reduce reentrained dust (Cowherd et al. 1977). However, Robert M. Bradway, Frank A. Record, and William E. Belanger, ("Monitoring and Modeling of Resuspended Roadway Dust near Urban Arterials," undated, GCA and U.S. EPA) found that vigorous, forced flushing, plus splashing by motor vehicles, redistributed particulates that had previously become concentrated adjacent to the curbs, and that many of these redistributed particulates became airborne as soon as the street became dry.

4. Adding curbs to paved streets reduces dust by about a factor of four (Cowherd et al. 1977).

SUMMARY

The above control strategies vary in effectiveness. It is estimated that it is not difficult to develop a strategy for the Baltimore area which will reduce fugitive emissions by 70 percent. Where fugitive emissions cause 50 percent of the TSP concentrations, this will result in a 35 percent reduction in TSP levels. At the three sites included in the microscopy analysis of this study, the fugitive emission component increased when the concentration increased. This phenomenon is best illustrated by the seven TSP measurements at the Fire Department #10 sampling station. Figure 4 shows how the mineral content of particulate samples increases as the TSP concentration increases. It is reasonable to expect that fugitive emission controls of the above sources will reduce as much as 70 percent of the highest concentrations. On this basis, it seems reasonable to expect that fugitive emission controls can be used to reduce TSP levels in the Baltimore by 50 percent and bring air quality in the area in compliance with Federal standards. This is a very preliminary and undetailed analysis of the problem. The nature of the results obtained suggests that an effective control strategy can be adopted. Suitable alternatives could be tested using the emission data obtained in this report and available air quality dispersion models.

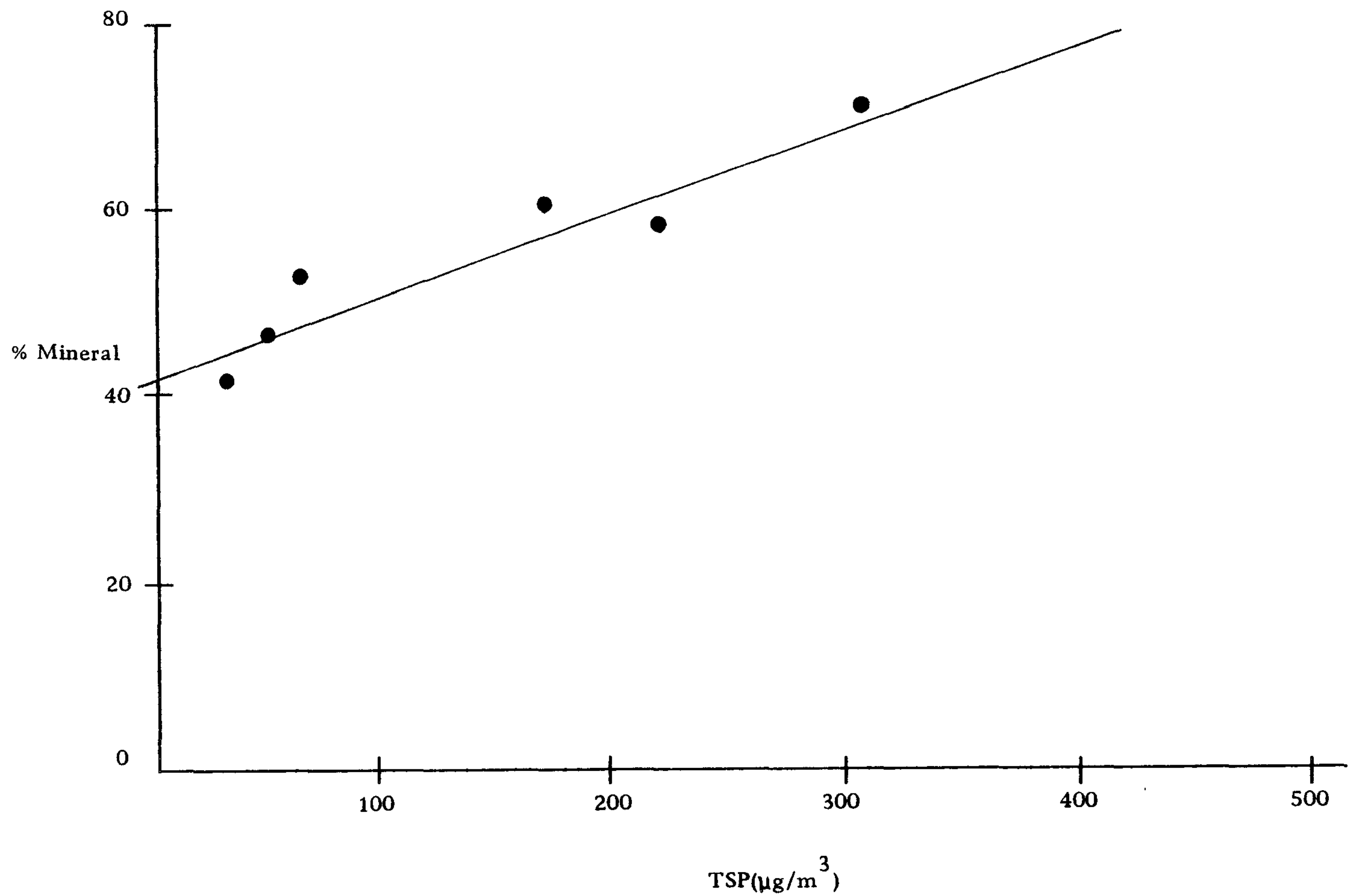

Figure 4. Observed Mineral Concentration As a Function of TSP Concentration at Fire Department #10 Hi-Vol Sampling Station

SECTION 7

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APPENDIX A

HI-VOL SAMPLING

HI-VOL FILTER HANDLING PROCEDURES

Changing of the hi-vol filter at the Fort McHenry site was observed. The procedure is as follows. Before traveling to the hi-vol site, the new glass fiber filters are removed from the mailing package and placed in a plastic box. Before the old filter is removed, the sampler is turned on for 2 to 3 minutes to let the flow stabilize; then, a flow meter reading is taken. The old filter is removed, carefully lifting the edges of the filter and placing it in a manila folder. The folder is clipped into a waxed envelope which is put in the plastic box. A new filter is removed from the plastic box and placed on the sampler. A final flow reading is taken after about 2 minutes of stabilization, and the timer is reset. The hi-vols are calibrated about every 6 months in the laboratory. The calibration procedure is included in this appendix. Hi-vol samples were normally taken every 6 days.

In the BAQNC laboratory, the filters are conditioned to a standard humidity level for at least 24 hours before being weighed. The filters are weighed before installation and after removal. Each filter received from the state in this study, except the blanks, was cut in two, and half of the filter was submitted to IITRI's laboratory for analysis of the particulate content. The other half of each filter was kept by GEOMET.

BAQNC PROCEDURE FOR CALIBRATING THE HI-VOL AIR SAMPLER

1. In order to obtain meaningful results from the hi-vol air sampler it is necessary to accurately determine the volume of air sampled as well as the weight of particulates. Since the rotameter is used only as an indicator of air flow and since only a small portion of the total air sampled passes through the rotameter during measurement, it must be calibrated against actual air flows.

2. Assemble the hi-vol sampler with a clean filter in place and run for at least 5 minutes. If new brushes are being used allow the sampler to run for one-half hour to insure proper seating. Attach the rotameter. Adjust the orifice at the top of the rotameter with the top brass screw so that the top of the ball reads 60. Lock the setting by tightening the brass lock nut at the top of the rotameter. Put sealing wax over the adjusting screw and lock nut to protect this setting. Check rotameter again for a flow of 60. Turn off the sampler and remove the filter paper.

3. Place the number 24 resistance plate into the mouth of the limiting orifice and then connect the orifice to the hi-vol air sampler. Rubber gaskets should be used before and after the resistance plate to

insure a leak proof seal. Connect the static pressure tap on the orifice to the manometer with flexible tubing, leaving one side of the manometer open to the atmosphere. Attach the sealed rotameter to the pressure tap at the base of the sampler by means of flexible tubing and quick-disconnects.

4. Turn the sampler on and run for at least five minutes. Observe and make note of the manometer readings. Repeat step 3 for plates #20, 18, 16, 14, 12 and 10. Tabulate the manometer and rotameter readings for each particular plate on the Hi-Vol Air Sampler Record Sheet.

5. Convert the manometer readings (ΔP) to actual air flow in cubic feet per minute (Q, cfm) by reference to the orifice calibration curve supplied with the calibration kit and tabulate these values.

6. The tabulated data (Q, cfm versus rotameter readings) are treated by the method of least squares to obtain the equation of the line that best fits the data when plotted. The State of Maryland presently accomplishes this by use of a computer program specifically written so that upon incorporation of the raw calibration data (Q, cfm versus rotameter readings) the equation of the line of best fit is obtained. This program is now available to all local air pollution agencies who desire to use it. If access to a computer is unavailable the data can be treated as in sections 8 and 9 of the aforementioned Federal Register or manually by the least squares method as follows:

6.1 Sum (ΣX) the column of flow meter readings including only those values for which manometer readings were on the orifice calibration curve ($\Delta P \geq 2.8$ inches).

6.2 Convert each air flow rate value (Q) in cubic feet per minute to cubic meters per minute (Y) by multiplying by 0.0283 $M^3/ft.^3$. Sum (ΣY) the column of air flow rate (Y) in cubic meters per minute.

6.3 Sum (ΣX^2) the squares of each of the air flow meter readings (X) for which the corresponding $\Delta P \geq 2.8$ inches.

6.4 Sum (ΣXY) the products of the corresponding flow meter readings (X) and the air flow rate (Y).

6.5 Perform the following calculations:

$$\Sigma Y = Na + b\Sigma X \qquad (1)$$

$$\Sigma(XY) = a\Sigma X + b\Sigma(X^2) \qquad (2)$$

where N is the total number of readings (X) which are being used in the calculations.

6.6 Substitute in equations (1) and (2) the values for ΣY, N, ΣX, $\Sigma(XY)$ and $\Sigma(X^2)$. Multiply equation (1) by the factor $\Sigma X/N$ to give the following equation:

$$\frac{\Sigma X \Sigma Y}{N} = a\Sigma X + b\,\frac{(\Sigma X)^2}{N} \qquad (3)$$

6.7 After substituting in the known numerical values, subtract equation (1) from equation (2). This eliminates unknown coefficient a. Coefficient b is then substituted into equation (1) and coefficient a is determined. The equation for the calibration line then turns out to be the following:

$$Y = bX + a \qquad (4)$$

where Y represents air flow rate in cubic meters per minute and X represents flow meter reading.

6.8 From equation (4) and the initial and final flow meter readings for a 24-hour sample, the total air volume sampled is calculated. The initial and final flow meter readings are averaged and the value (X) is incorporated in the calibration equation. The air flow Y multiplied by the total sampling time in minutes gives the total air volume sampled in cubic meters.

Appendix B

FUGITIVE EMISSION SURVEY FORM

FUGITIVE DUST SOURCE - REGISTRATION

Source No. __________

Map No. __________ Map Coord. __________

Grid Coordinates ____________________

Description of Area:

Paved Lot

- ☐ Asphalt
- ☐ Concrete
- ☐ Stone & Tar
- ☐ Trash & Debris
- ☐ Unpaved Shoulders
- ☐ Loose Gravel Surface
- ☐ Stockpiles with Fine Material
- ☐ Stockpiles with Course Material
- ☐ Other

Unpaved Lot

- ☐ Dirt
- ☐ Grass
- ☐ Weeds
- ☐ Crushed Stone
- ☐ Gravel
- ☐ Broken Pavement
- ☐ Cinder
- ☐ Trash & Debris
- ☐ Stockpiles with Fine Material
- ☐ Stockpiles with Course Material
- ☐ Other

Terrain:

- ☐ Flat
- ☐ Rolling
- ☐ Steep Slopes
- ☐ Open
- ☐ Enclosed
- ☐ Semi-enclosed

Approximate Size __________' X __________'

Type of Activity:

- ☐ Residential
- ☐ Commercial
- ☐ Industrial
- ☐ Parking
- ☐ Construction
- ☐ Storage
- ☐ Recreation
- ☐ Unused
- ☐ Railroad

Cinder, Gravel Crushed Stone, Oiled
Not Oiled

☐ Res.

☐ Comm.

☐ Ind.

☐ Res. ☐ Comm. ☐ Ind.		☐ Res. ☐ Comm. ☐ Ind.

☐ Res.

☐ Comm.

☐ Ind.

Description of Emissions

☐ Cars

☐ Trucks

☐ Stockpiles

☐ Storage

☐ Natural Occurrence

☐ Material Handlers

- ☐ Mobile
- ☐ Stationary

☐ Other ______________

Inspectors Comments: ____________

____

____

Date Registered: ____________

By: ______________________

Mobile Activities Frequency

☐ Commuter

☐ Continuous

☐ Occasional (Low Activity)

☐ Occasional (High Activity - Bulk)

No. of Vehicles per Unit Time __________

Avg. Speed of Vehicle __________

Stockpiles moved 24 Hr. ☐ Wkly. ☐ Mthly. ☐

Owner Information:

Name: ____________	Tel. No. ________
Address: ____________	
Leased: ____________	

Estimated Emissions:

__________ lbs/day

Appendix C

FUGITIVE SOURCE CHARACTERISTICS

This appendix contains the following data:

- Baltimore City fugitive source characteristics by grid square (1 square mile each)
- UTM and Maryland state coordinates for each Baltimore City grid square
- Baltimore and Anne Arundel fugitive source characteristics by grid square (1000 ft on a side).

Baltimore City

Fugitive Source Characteristics

GRID NO.	PAVED ROADS	GRAVEL ROADS		DIRT ROADS			CONSTR SITES	WIND EROSION			RAILROADS	
	THOUSAND VMT PER DAY	VMT PER DAY	VEHICLE SPEED (MPH)	SILT (%)	VMT PER DAY	VEHICLE SPEED (MPH)	AREA (ACRE)	SURFACE ERODIBILITY (TON/ACRE/YR)	SILT (%)	AREA (ACRE)	VMT PER DAY	VEHICLE SPEED (MPH)
1	38.30											
2	47.60											
3	59.30											
4	53.90											
5	47.50											
6	53.80											
7	60.00											
8	41.10											
9	41.20											
10	24.70											
11	35.70											
12	58.70											
13	67.20											
14	58.10											
15	47.50											
16	39.30											
17	52.70											
18	30.90											
19	34.40											
20	43.40											
21	29.30											
22	35.00											
23	73.00											
24	96.60											
25	104.40											
26	68.60											
27	66.70											
28	43.10											
29	62.70											
30	38.60											
31	29.30											
32	31.40											
33	24.00											
34	30.10											
35	112.00											
36	95.70											
37	90.10											
38	40.70	221.00	10					38	12	0.2		
38								53	72	5.2		
39	54.80			72	14.00	10	10.0	53	72	8.5		
40	38.60	5.00	10	72	3.30	10		72		3.7		
41	40.40											
42	49.10											
43	56.30	212.00	10	62	156.00	10		52	62	15.2		15
44	52.50	47.00	10	62	10.30	10	0.4	52	62	42.0		15
44				62	156.00	10		38	12	19.9		

FUGITIVE SOURCE CHARACTERISTICS

GRID NO.	PAVED ROADS: THOUSAND VMT PER DAY	GRAVEL ROADS: VMT PER DAY	GRAVEL ROADS: VEHICLE SPEED (MPH)	DIRT ROADS: SILT (%)	DIRT ROADS: VMT PER DAY	DIRT ROADS: VEHICLE SPEED (MPH)	CONSTR SITES: AREA (ACRE)	WIND EROSION: SURFACE ERODIBILITY (TON/ACRE/YR)	WIND EROSION: SILT (%)	WIND EROSION: AREA (ACRE)	RAILROADS: VMT PER DAY	RAILROADS: VEHICLE SPEED (MPH)
45	88.90	28.00	10	62		10	3.1	52	62	9.5		15
46	120.20	958.00	10	65	1.00	25	12.3	38	12	4.1		15
47	85.60	273.00	10	65	15.00	10	10.8	55	65	0.6		15
47								38	12	0.5		
48	73.50	211.00	10				0.4	55	65	7.0		15
48								38	12	3.5		
49	63.90	15.51	10	65	9.00	5		38	12	4.3	217.00	15
49		237.00	5					55	65	6.4		
49								50	30	2.0 C		
50	33.50	914.00	10	65	1193.18	25		50	65	5.2		15
50				65	37.00	10						
51	66.90											
52	38.50											
53	55.10	1124.00	5	62	283.00	10		38	12	9.1		15
53								52	62	11.4		
54	56.10	266.00	10				12.1	52	62	4.4		15
55	123.50	35.00	10	62	1882.00	10	30.7	52	62	27.3	82.67	15
55								50	30	15.5 C		
56	144.50	1654.00	10	65	200.00	10	4.2	55	65	9.0		15
57	64.30							55	65	3.2		
58	54.20	1734.00	10	65	6.00	10		55	65	9.5		15
58								38	12	4.5		
59	45.30	760.00	10	65	4.74	10		55	65	50.8	9.30	15
59								38	12	13.7		
60	29.70	772.00	10				1.6	55	65	28.0	9.30	15
61	29.70											
62	36.80											
63	45.00	11.00	10	62	5.00	10	11.9	38	12	15.6		15
63								52	62	21.2		
64	70.60	491.00	10				10.9	52	62	8.8	165.33	15
64								50	30	0.1 C		
65	77.60	1271.00	10	62	15.72	10	9.3	52	62	23.4		15
65				62	300.00	25		38	12	20.9		
66	63.70	1713.00	10	65	32.00	10	3.3	55	65	9.9		15
67	28.20	1220.00	10	65	135.00	25	1.3	38	12	4.0	284.00	15
67								55	65	4.5		
68	46.00	136.36	25	65	4.36	15	0.7	38	12	4.4	41.08	15
68		4.00	10					55	65	32.4		
68								50	30	2.2 O		
69	45.30	31.00	10	65	602.00	30	9.4	38	12	20.8		15
69				65	50.00	10		55	65	18.9		
70	29.70	19.00	10									
72	12.40											
73	25.70	135.00	15	62	117.00	10	4.6	52	62	23.9		25
74	48.30	86.00	10				0.5					15
75	33.80	371.00	10	62	159.00	10	38.3	38	12	13.3		

FUGITIVE SOURCE CHARACTERISTICS

GRID NO.	PAVED ROADS	GRAVEL ROADS		DIRT ROADS			CONSTR SITES	WIND EROSION			RAILROADS	
	THOUSAND VMT PER DAY	VMT PER DAY	VEHICLE SPEED (MPH)	SILT (%)	VMT PER DAY	VEHICLE SPEED (MPH)	AREA (ACRE)	SURFACE ERODIBILITY (TON/ACRE/YR)	SILT (%)	AREA (ACRE)	VMT PER DAY	VEHICLE SPEED (MPH)
76	13.30	139.00	10	65	1.00	10		38	12	1.9	93.00	15
76								55	65	1.3		
76								50	30	0.9 0		
77	13.30	999.00	10				17.1	55	65	2.8	142.00	15
78	42.50	651.00	10	65	272.87	20		55	65	8.7	41.08	15
78								38	12	9.0		
78								50	30	5.8 0		
79	45.30	3952.00	10	65	1100.00	20	1.1	55	65	30.0		15
79		1.20	20					38	12	12.4		
80	29.70	2298.00	10	65	124.00	25		38	12	15.7		15
83	2.80											
84	22.60	2633.00	10									15
85	42.30			62	5.00	10	38.3	38	62	48.7		15
86	47.40	971.00	10	65	167.00	10	0.6	38	12	5.8		15
87	32.90											15
88	45.30	417.00	10	65	185.00	10		55	65	5.5		10
88								38	12	15.5		
90	29.70											
95	4.20											
96	27.70	1212.00	10				0.7	38	12	0.7		
97	32.90	1049.00	10					38	12	19.5	682.00	15
97								50	30	22.4 C		
97								50	30	1.1 0		
98	32.90	2380.00	25									15
106	6.70			65	32.00	10		50	65	5.2		
107	27.70	39.00	10				9.0	38	12	1.7		15
108	32.90	96.00	10									15
109	32.90							38	12	229.6		15
117	13.70	1.52	20					38	12	10.2		15
118	25.90	224.00	10									15
119	27.70	5956.00	5									15
120	15.50	352.00	10	65		10						15

THE 1975 REGIONAL PLANNING COUNCIL ESTIMATES OF AVERAGE WEEKDAY VEHICLE-MILES-OF-TRAVEL (VMT) FOR PAVED ROADS INCLUDE AUTO TRAVEL ON FREEWAYS AND ARTERIAL ROADS. TRUCK TRAVEL, INTRA-RPD (REGIONAL PLANNING DISTRICT) TRAVEL, AND OTHER TRAVEL ON LOCAL AND COLLECTOR STREETS ARE NOT INCLUDED.

A 12% SILT CONTENT IS ASSUMED FOR PAVED ROADS, GRAVEL ROADS, AND RAILROAD BEDS. A 1-1/2 TON AVERAGE VEHICLE WEIGHT IS ASSUMED FOR PAVED ROADS. THE SURFACE DUST LOADING ON TRAVELED PORTION OF PAVED ROAD IS ASSUMED TO BE 17.7 LB/MILE. 112 DAYS OF THE YEAR ARE ASSUMED TO BE WET IN BALTIMORE.

THORNTHWAITE'S PRECIPITATION-EVAPORATION INDEX (PE) FOR BALTIMORE IS 108.

THE % TIME THAT THE SURFACE WIND SPEED EXCEEDS 12 MILES PER HOUR IS 21.4 FOR BALTIMORE.

THE LETTERS "C" AND "O" ARE USED TO INDICATE WIND EROSION FOR COAL AND ORE SURFACES RESPECTIVELY.

ALL INPUT INFORMATION EXCEPT SURFACE SOIL SILT AND ERODIBILITY CONTENTS, AND RAILROAD AND PAVED ROAD VMT WERE FURNISHED BY THE BAQNC SURVEY. FOR OTHER INFORMATION SEE THE NOTES ON THE OUTPUT SHEET.

GRID NUMBER ***********	X/Y ***	UTM ********	MARYLAND ********	GRID NUMBER ***********	X/Y ***	UTM ********	MARYLAND ********	GRID NUMBER ***********	X/Y ***	UTM ********	MARYLAND ********
1	X	353280.	884740.	18	X	364667.	922105.	35	X	359807.	906185.
	Y	4358110.	557370.		Y	4356480.	552105.		Y	4353201.	541315.
2	X	354964.	890265.	19	X	366272.	927370.	36	X	361451.	911580.
	Y	4358106.	557370.		Y	4356477.	552105.		Y	4353198.	541315.
3	X	356568.	895525.	20	X	367876.	932630.	37	X	363055.	916840.
	Y	4358103.	557370.		Y	4356473.	552105.		Y	4353194.	541315.
4	X	358173.	900790.	21	X	353273.	884740.	38	X	364660.	922105.
	Y	4358099.	557370.		Y	4354860.	546710.		Y	4353191.	541315.
5	X	359818.	906185.	22	X	354957.	890265.	39	X	366265.	927370.
	Y	4358096.	557370.		Y	4354856.	546710.		Y	4353187.	541315.
6	X	361462.	911580.	23	X	356561.	895525.	40	X	367868.	932630.
	Y	4358092.	557370.		Y	4354853.	546710.		Y	4353184.	541315.
7	X	363066.	916840.	24	X	358166.	900790.	41	X	353266.	884740.
	Y	4358088.	557370.		Y	4354850.	546710.		Y	4351571.	535920.
8	X	364671.	922105.	25	X	359810.	906185.	42	X	354950.	890265.
	Y	4358084.	557370.		Y	4354846.	546710.		Y	4351567.	535920.
9	X	366276.	927370.	26	X	361455.	911580.	43	X	356554.	895525.
	Y	4358081.	557370.		Y	4354842.	546710.		Y	4351564.	535920.
10	X	367879.	932630.	27	X	363058.	916840.	44	X	358159.	900790.
	Y	4358078.	557370.		Y	4354839.	546710.		Y	4351560.	535920.
11	X	353277.	884740.	28	X	364663.	922105.	45	X	359803.	906185.
	Y	4356505.	552105.		Y	4354835.	546710.		Y	4351557.	535920.
12	X	354961.	890265.	29	X	366268.	927370.	46	X	361448.	911580.
	Y	4356501.	552105.		Y	4354832.	546710.		Y	4351553.	535920.
13	X	356564.	895525.	30	X	367872.	932630.	47	X	363051.	916840.
	Y	4356498.	552105.		Y	4354828.	546710.		Y	4351550.	535920.
14	X	358169.	900790.	31	X	353269.	884740.	48	X	364656.	922105.
	Y	4356494.	552105.		Y	4353216.	541315.		Y	4351546.	535920.
15	X	359814.	906185.	32	X	354954.	890265.	49	X	366261.	927370.
	Y	4356491.	552105.		Y	4353212.	541315.		Y	4351543.	535920.
16	X	361459.	911580.	33	X	356557.	895525.	50	X	367865.	932630.
	Y	4356486.	552105.		Y	4353208.	541315.		Y	4351539.	535920.
17	X	363062.	916840.	34	X	358162.	900790.	51	X	353262.	884740.
	Y	4356484.	552105.		Y	4353205.	541315.		Y	4349926.	530525.

(continued)

GRID NUMBER ***********	X/Y ***	UTM ********	MARYLAND ********
52	X	354947.	890265.
	Y	4349923.	530525.
53	X	356550.	895525.
	Y	4349919.	530525.
54	X	358155.	900790.
	Y	4349916.	530525.
55	X	359800.	906185.
	Y	4349912.	530525.
56	X	361444.	911580.
	Y	4349908.	530525.
57	X	363048.	916840.
	Y	4349905.	530525.
58	X	364653.	922105.
	Y	4349901.	530525.
59	X	366258.	927370.
	Y	4349898.	530525.
60	X	367861.	932630.
	Y	4349894.	530525.
61	X	353259.	884740.
	Y	4348323.	525265.
62	X	354943.	890265.
	Y	4348319.	525265.
63	X	356547.	895525.
	Y	4348316.	525265.
64	X	358152.	900790.
	Y	4348312.	525265.
65	X	359796.	906185.
	Y	4348309.	525265.
66	X	361441.	911580.
	Y	4348305.	525265.
67	X	363044.	916840.
	Y	4348302.	525265.
68	X	364649.	922105.
	Y	4348298.	525265.

GRID NUMBER ***********	X/Y ***	UTM ********	MARYLAND ********
69	X	366254.	927370.
	Y	4348295.	525265.
70	X	367858.	932630.
	Y	4348291.	525265.
72	X	354939.	890265.
	Y	4346675.	519870.
73	X	356543.	895525.
	Y	4346671.	519870.
74	X	358148.	900790.
	Y	4346668.	519870.
75	X	359793.	906185.
	Y	4346664.	519870.
76	X	361437.	911580.
	Y	4346660.	519870.
77	X	363041.	916840.
	Y	4346657.	519870.
78	X	364646.	922105.
	Y	4346653.	519870.
79	X	366251.	927370.
	Y	4346650.	519870.
80	X	367854.	932630.
	Y	4346646.	519870.
83	X	356539.	895525.
	Y	4345026.	514475.
84	X	358144.	900790.
	Y	4345023.	514475.
85	X	359789.	906185.
	Y	4345019.	514475.
86	X	361434.	911580.
	Y	4345016.	514475.
87	X	363037.	916840.
	Y	4345012.	514475.
88	X	364642.	922105.
	Y	4345009.	514475.

GRID NUMBER ***********	X/Y ***	UTM ********	MARYLAND ********
90	X	367850.	932630.
	Y	4345002.	514475.
95	X	359786.	906185.
	Y	4343454.	509340.
96	X	361430.	911580.
	Y	4343450.	509340.
97	X	363034.	916840.
	Y	4343447.	509340.
98	X	364639.	922105.
	Y	4343443.	509340.
106	X	361427.	911580.
	Y	4341847.	504080.
107	X	363030.	916840.
	Y	4341843.	504080.
108	X	364635.	922105.
	Y	4341840.	504080.
109	X	366240.	927370.
	Y	4341836.	504080.
117	X	363027.	916840.
	Y	4340238.	498815.
118	X	364632.	922105.
	Y	4340235.	498815.
119	X	366237.	927370.
	Y	4340231.	498815.
120	X	367840.	932630.
	Y	4340228.	498815.

Note: Coordinates are for center of each grid.

FUGITIVE SOURCE CHARACTERISTICS

MARYLAND COORDINATES THOUSANDS OF FEET X	Y	GRAVEL ROADS VMT PER DAY	GRAVEL ROADS VEHICLE SPEED (MPH)	DIRT ROADS SILT (%)	DIRT ROADS VMT PER DAY	DIRT ROADS VEHICLE SPEED (MPH)	CONSTR SITES AREA (ACRE)	WIND EROSION SURFACE ERODIBILITY (TON/ACRE/YR)	WIND EROSION SILT (%)	WIND EROSION AREA (ACRE)	RAILROADS VEHICLE SPEED (MPH)
891	509	10.00	10					50	70	3.7	
891	510										40
891	513	7.50	10					60	60	0.5	
891	515							86	40	8.6	
892	508							38	12	0.3	
892	508							40	75	0.6	
892	510							47	75	0.3	40
892	512						0.8				
892	513	120.00	10								
892	517							86	40	48.5	
893	509							40	75	1.2	
893	511	120.00	10								40
893	512							50	70	2.9	40
893	513	100.00	10					60	60	1.7	
893	516							86	40	11.7	
893	517	2.50	10					86	40	0.9	
893	519	17.50	10					60	60	16.5	
894	509							47	70	11.9	
894	513	2.50	10					60	60	0.4	
894	513	300.00	10					50	70	1.5	
894	516							60	60	3.9	40
894	517							86	40	0.2	
894	518							60	60	1.7	
894	519	5.00	5								
895	508							86	40	10.4	
895	511	60.00	10								
895	516	7.50	10								
895	519							60	60	1.4	
896	506	38.00	10								
896	510						1.0				
896	511	2.50	10					47	70	0.6	
896	516							60	60	0.7	
896	516							60	60	0.8	
896	517	5.00	10					60	60	1.8	
897	507						10.1				
897	511							60	60	1.2	
898	510							60	60	2.5	
898	514							60	60	24.8	
898	515							47	70	0.1	
899	512						0.5				
899	512						0.7				
900	509	50.00	10					86	40	1.1	
900	510						2.3				
900	514	2.50	10								
900	516	5.00	10								
901	496							134	20	0.3	

FUGITIVE SOURCE CHARACTERISTICS

MARYLAND COORDINATES THOUSANDS OF FEET X	Y	GRAVEL ROADS VMT PER DAY	GRAVEL ROADS VEHICLE SPEED (MPH)	DIRT ROADS SILT (%)	DIRT ROADS VMT PER DAY	DIRT ROADS VEHICLE SPEED (MPH)	CONSTR SITES AREA (ACRE)	WIND EROSION SURFACE ERODIBILITY (TON/ACRE/YR)	WIND EROSION SILT (%)	WIND EROSION AREA (ACRE)	RAILROADS VEHICLE SPEED (MPH)
901	497							38	12	0.9	
901	501	30.00	5				1.4				
901	509							86	40	1.1	
901	512							47	75	0.7	
901	513							60	60	0.2	
901	514	1.00	10								
902	495							86	40	4.5	
902	496							38	12	2.0	
902	501	355.00	10								
902	508							38	12	0.3	
902	515	20.00	10								
902	515	20.00	10								
903	508	23.00	10					86	40	1.4	
903	509							220	15	3.4	
903	514	7.50	10								
906	496							86	40	65.1	
906	504			30	43.00	5		86	30	7.7	
906	507							86	50	5.5	
906	508							86	40	0.0	
906	512							220	15	2.8	
906	513						40.2				
907	507	597.00	10								
908	482							134	15	10.0	
908	492							86	40	0.1	
908	494			40	420.00	5		50	40	10.2	
909	491			20		5		50	20	1.5	
909	505							47	75	1.7	
910	484							134	15	1.1	
911	485	3.00	10								
911	493						6.4				
912	502	2.50	10								
913	474	237.00	10								
913	477	38.00	10					134	15	3.7	
913	477	5.00	10								
913	482	57.00	5					38	12	9.2	
914	497			50	0.90	5		40	50	0.5	
914	500							47	75	1.8	
915	479	10.00	10								
916	488							134	15	1.1	
917	474	20.00	5					86	40	17.5	
917	477							47	75	1.1	
917	479						23.0				
917	499			50	160.00	20		50	50	3.9	
918	474						0.1				
918	499			40	11.00	40		50	40	3.4	
919	475							134	25	11.5	

FUGITIVE SOURCE CHARACTERISTICS

MARYLAND COORDINATES (THOUSANDS OF FEET) X	Y	GRAVEL ROADS VMT PER DAY	GRAVEL ROADS VEHICLE SPEED (MPH)	DIRT ROADS SILT (%)	DIRT ROADS VMT PER DAY	DIRT ROADS VEHICLE SPEED (MPH)	CONSTR SITES AREA (ACRE)	WIND EROSION SURFACE ERODIBILITY (TON/ACRE/YR)	WIND EROSION SILT (%)	WIND EROSION AREA (ACRE)	RAILROADS VEHICLE SPEED (MPH)
919	476			25	3.00	12		134	25	1.2	
919	497			80	28.00	40		50	80	1.5	
921	478							220	50	0.5	
921	498	15.00	5								
921	498	1000.00	5								
922	474							38	12	0.9	
922	480							86	45	50.1	
922	483						0.7				
923	483			80	1.50	25		50	80	1.5	
925	482							86	35	0.2	
926	475							134	15	0.5	
926	494						3.0				
927	481	2.50	10								
930	479							220	5	0.9	
930	497	5600.00	10								
931	478							134	15	0.7	
931	488	19.00	10								
931	494						9.8				
932	473	2.50	10								
932	484							134	15	0.2	
933	437	400.00	40								
933	474							220	5	0.7	
933	518							86	40	0.3	40
933	534							38	12	22.0	
933	537							38	12	1.0	
934	519							86	40	0.6	
934	523	20.00	10								40
934	524										40
934	534	5.00	25								
934	535	35.00	10					47	60	1.4	
934	572	900.00	10					86	30	22.1	
935	517	50.00	10								
935	518	140.00	10								
935	523	200.00	10								40
935	524						1.9				
936	472							38	12	1.8	
936	484							134	25	0.7	
936	485	2.50	10								
936	516							38	12	3.7	
936	519										40
936	520							86	40	0.4	
936	522	80.00	10								40
936	523	20.00	10								
936	525	2.50	10								
936	536	5.00	10					86	40	0.9	
936	537							38	12	60.6	
936	537							86	40	27.3	

FUGITIVE SOURCE CHARACTERISTICS

MARYLAND COORDINATES THOUSANDS OF FEET X	Y	GRAVEL ROADS VMT PER DAY	GRAVEL ROADS VEHICLE SPEED (MPH)	DIRT ROADS SILT (%)	DIRT ROADS VMT PER DAY	DIRT ROADS VEHICLE SPEED (MPH)	CONSTR SITES AREA (ACRE)	WIND EROSION SURFACE ERODIBILITY (TON/ACRE/YR)	WIND EROSION SILT (%)	WIND EROSION AREA (ACRE)	RAILROADS VEHICLE SPEED (MPH)
936	571							47	95	2.4	40
937	485						1.2				
937	513	40.00	10								
937	514							38	12	2.3	
937	520			40	60.00	10		50	40	1.5	
937	525							86	40	0.2	
937	528							86	30	2.1	
937	543						7.8				
938	479							38	12	0.7	
938	487	2.50	25								
938	511	1000.00	10								40
938	512	200.00	10								40
938	519							86	40	0.4	
938	520	5.00	10					47	75	0.2	
938	520	20.00	5					86	40	1.1	
938	521						7.7				
938	522			60	40.00	10		50	60	1.0	
938	524			60	2.50	10		50	60	0.5	
938	525	20.00	10								
938	527							86	30	12.7	
938	530							86	30	0.3	
938	532							47	75	0.3	
938	542	40.00	10					47	70	0.4	
939	479							38	12	0.6	
939	485						0.2				
939	513	80.00	10					220	50	0.1	
939	514	2.50	10				6.9				
939	515	20.00	10								
939	518							86	40	1.4	
939	519							134	25	2.3	
939	522						3.8				
939	525							60	60	0.6	
939	537										40
940	515	25.00	10					86	40	0.4	
940	517		10					86	45	2.5	
940	519										40
940	525							47	75	0.8	
940	530	2.50	10								
940	530	5.00	10								
940	534							47	70	1.5	
940	534							38	12	4.1	
940	534							86	40	3.7	
940	538							38	12	4.5	
940	543							47	75	1.1	
941	475							110	25	187.4	
941	481							20	52	0.7	

FUGITIVE SOURCE CHARACTERISTICS

MARYLAND COORDINATES THOUSANDS OF FEET X	Y	GRAVEL ROADS VMT PER DAY	GRAVEL ROADS VEHICLE SPEED (MPH)	DIRT ROADS SILT (%)	DIRT ROADS VMT PER DAY	DIRT ROADS VEHICLE SPEED (MPH)	CONSTR SITES AREA (ACRE)	WIND EROSION SURFACE ERODIBILITY (TON/ACRE/YR)	WIND EROSION SILT (%)	WIND EROSION AREA (ACRE)	RAILROADS VEHICLE SPEED (MPH)
941	511							47	75	1.6	
941	513						4.6				
941	517							38	12	11.7	
941	518										40
941	520							86	40	2.4	
941	523							86	40	2.3	
941	524							86	40	4.6	
941	528							86	40	3.7	
941	529	20.00	5					86	40	1.0	
941	534	10.00	10								
941	543	1400.00	10								
942	481	80.00	25								
942	514				2.50	10		50	60	0.5	
942	518										40
942	519	900.00	10	40	900.00	10		50	40	31.5	
942	519	23.00	10	40	50.00	10					
942	521							86	40	1.6	
942	529	38.00	10					47	75	1.0	
942	533			50	400.00			50	50	38.8	
942	538	10.00	10					38	12	1.1	
942	538							86	40	2.1	
942	544	10.00	10					60	60	1.1	40
943	480	80.00	25								
943	517	25.00	10								
943	528							38	12	0.3	
943	528							50	70	2.8	
943	529	100.00	20								
943	535							38	12	2.3	
943	535							86	40	4.5	
943	544	7.50	10					60	60	1.6	
943	545	2.50	10					60	60	0.3	
943	546							60	60	1.4	
944	517	10.00	10								40
944	518							47	75	3.1	
944	520							86	40	1.1	
945	483						0.2				
945	529			50	20.00	10		50	50	0.5	
945	530	20.00	10								
945	544							60	60	49.6	
946	515							220	50	68.9	40
946	521	2.50	5								
946	529	50.00	10					38	12	0.9	
947	521	5.00	15								
947	525							47	75	3.4	
948	515	2.50	10								
948	524							47	70	1.1	

FUGITIVE SOURCE CHARACTERISTICS

MARYLAND COORDINATES THOUSANDS OF FEET X	Y	GRAVEL ROADS VMT PER DAY	GRAVEL ROADS VEHICLE SPEED (MPH)	DIRT ROADS SILT (%)	DIRT ROADS VMT PER DAY	DIRT ROADS VEHICLE SPEED (MPH)	CONSTR SITES AREA (ACRE)	WIND EROSION SURFACE ERODIBILITY (TON/ACRE/YR)	WIND EROSION SILT (%)	WIND EROSION AREA (ACRE)	RAILROADS VEHICLE SPEED (MPH)
948	525							47	75	4.6	
948	526	2.50	10								
948	529						76.7				
949	523							47	75	1.1	
949	524	10.00	10								
949	525	60.00	10					38	12	0.3	
949	525							47	75	0.1	
949	525							220	50	0.1	
949	526	400.00	10								
950	520	2.50	5								
950	522	2.50	10	75	2.50	10		50	75	0.5	
950	523	5.00	10	75	5.00	10		50	75	1.0	
950	523	60.00	10	50	60.00	10		50	50	1.5	
950	523	60.00	10								
950	524	3.00	5	75	15.00	5		47	80	2.5	
950	525	8.00	10								
950	527	120.00	10	50	120.00	10		50	50	2.9	
950	528	25.00	10								
951	524							220	50	2.1	
952	510	2.50	5								40
952	510	2.50	5								40
952	510	2.50	5								
952	515										40
952	516	460.00	10								
952	518	240.00	10								
952	520	15.00	10								
952	521	2.50	10								
952	521	7.50	10								
952	523	95.50	10								
952	526	100.00	10								
953	505							38	12	0.4	
953	510	2.50	5	75	2.50	10		47	75	0.6	40
953	510	2.50	10								
953	510	2.50	5								
953	510	2.50	5								
953	510	2.50	5								
953	512	220.00	10								
953	517	7.50	10								
953	526	130.00	10	50	130.00	10		50	50	12.6	
954	505							38	12	0.2	
954	510	2.50	5								
954	510	2.50	5								
954	510	2.50	5								
954	510	2.50	5								
954	510	2.50	5								
954	511							38	12	6.2	

FUGITIVE SOURCE CHARACTERISTICS

MARYLAND COORDINATES THOUSANDS OF FEET X	Y	GRAVEL ROADS VMT PER DAY	GRAVEL ROADS VEHICLE SPEED (MPH)	DIRT ROADS SILT (%)	DIRT ROADS VMT PER DAY	DIRT ROADS VEHICLE SPEED (MPH)	CONSTR SITES AREA (ACRE)	WIND EROSION SURFACE ERODIBILITY (TON/ACRE/YR)	WIND EROSION SILT (%)	WIND EROSION AREA (ACRE)	RAILROADS VEHICLE SPEED (MPH)
954	520										40
954	522							38	12	29.6	
954	524							47	75	40.4	
954	525	30.00	10								
955	505							38	12	0.7	
955	510	20.00	5								
955	510	2.50	5								
955	510	2.50	5								
955	510	15.00	5								
955	510	2.50	5								
955	511	5.00	10				2.0				
955	511	20.00	5								
955	511	2.50	10								
955	511	2.50	10								
955	514	40.00	5								
955	517							86	45	13.5	
955	518	2.50	10								
955	520	2.50	10								
956	508						6.4				
956	510							38	12	0.4	
956	510							47	75	0.4	
956	512	2.50	10								
957	501	2.50	10								
957	506							47	75	1.1	
957	511	10.00	10								
957	512	5.00	10								
958	510							38	12	7.1	
958	511	5.00	10								
958	511	40.00	10								
958	512	2.50	10								
958	513	200.00	10								
958	513	2.50	10								
959	513							220	50	2.1	
960	509							86	45	18.4	
961	509	1.00	10								
961	509	2.50	5								
962	509							86	45	8.3	
969	510	7.50	10								
969	511							38	12	0.2	
970	512	5.00	10								

THE CO-ORDINATES ARE FOR INDIVIDUAL LOTS THAT WERE SURVEYED BY BAQNC IN ANNE ARUNDEL AND BALTIMORE COUNTIES, AND ARE TAKEN ROUGHLY AT THE CENTER OF EACH LOT. BECAUSE OF THE COMBINATION METHOD USED, THE NUMBER OF LOTS WITH THE SAME CO-ORDINATES DO NOT REPRESENT THE ACTUAL NUMBER OF LOTS SURVEYED BY BAQNC.

A 12% SILT CONTENT IS ASSUMED FOR GRAVEL ROADS AND RAILROAD BEDS. 112 DAYS OF THE YEAR ARE ASSUMED TO BE WET IN BALTIMORE.

THORNTHWAITE'S PRECIPITATION-EVAPORATION INDEX (PE) FOR BALTIMORE IS 108.

THE % TIME THAT THE SURFACE WIND SPEED EXCEEDS 12 MILES PER HOUR IS 21.4 FOR BALTIMORE.

ALL INPUT INFORMATION EXCEPT SURFACE SOIL SILT AND ERODIBILITY CONTENTS WERE FURNISHED BY THE BAQNC SURVEY.

FOR OTHER INFORMATION SEE THE FINAL REPORT, AND THE NOTES ON THE OUTPUT SHEET.

Appendix D

FUGITIVE EMISSION PROGRAMS

The appendix contains listings of FORTRAN computer programs to compute emissions of fugitive sources and to compute coordinate conversions. The following are included:

- Program to compute fugitive emissions for Baltimore City
- Program to compute fugitive emissions for Anne Arundel and Baltimore Counties
- Program to compute UTM coordinates from Maryland state coordinates.

```
      C
      C         BALTIMORE CITY
      C
      C         THIS PROGRAM IS SET UP TO READ IN VARIOUS PARAMETERS FOR
      C         UP TO 7 DIFFERENT SOURCES, CALCULATE EMISSIONS, THEN PRINT
      C         OUT INPUT INFO, EMISSIONS, AND TOTAL EMISSIONS BY UNIT.
      C
      C         VARIABLES:
      C         SOURCE:  EMISSION SOURCE TYPE
      C         SQFT  :  SQUARE FOOTAGE
      C         SILT  :  % SILT
      C         SSE   :  SURFACE SOIL ERODIBILITY
      C         AVS   :  AVERAGE VEHICLE SPEED
      C         VMT   :  VEHICLE MILES TRAVELLED
      C         TYPE  :  MATERIAL TYPE
      C         GRID  :  GRID NUMBER (1-120)
      C         ACRES :  NO. ACRES CONVERTED FROM SQFT
      C         TOTAL1:  LB/DAY
      C         NC    :  NUMBER OF CARDS PER SOURCE TYPE
      C
0001            INTEGER*4 ISQFT
0002            REAL*8 RR1A,RR2A,TOTL2A
0003            DIMENSION SVMT(10,6),SACRES(10,6),SP(6),KSILT(10,6),
             *  KTYPE(10,6),KSSE(10,6),KAVS(10,6)
0004            NC = 6
0005            IC6 = 0
0006            IC3 = 0
0007            I1 = 0
0008            I2 = 0
0009            I3 = 0
0010            I4 = 0
0011            I5 = 0
0012            I6 = 0
0013            I7 = 0
0014            TOT1 = 0.0
0015            SUM1 = 0.0
0016            SUM2 = 0.0
0017            SUM3 = 0.0
0018            SUM4 = 0.0
0019            SUM5 = 0.0
0020            SUM6 = 0.0
0021            SUM7 = 0.0
0022            DO 4 J1=1,NC
0023          4 SP(J1) = 0.0
0024            TOTAL1 = 0.
0025            PR = 0.0
0026            GR = 0.0
0027            DR = 0.0
0028            CS = 0.0
0029            NE = 0.0
0030            RR1 = 0.0
0031            RR2 = 0.0
0032            DO 7 J=1,NC
0033            DO 6 K=1,10
0034            KSILT(K,J) = 0
0035            KTYPE(K,J) = 0
```

```
              KSSE(K,J)  = 0
              KAVS(K,J)= 0
              SVMT(K,J)  = 0.
              SACRES(K,J)= 0.
        6     CONTINUE
        7     CONTINUE
              EOF = 0
              OPEN (UNIT=1,NAME='EMISS.SRT',TYPE='OLD',READONLY)
              OPEN (UNIT=2,NAME='SSCONV.DAT',TYPE='OLD',READONLY)
              TYPE 100
      100     FORMAT (' NUMBER OF EMISSION SOURCES INPUT:')
              ACCEPT *,NS
              IF (NS.GT.7) STOP ' NUMBER SOURCES EXCEED LIMIT OF 7'
              WRITE (6,500)
              WRITE (3,600)
        8     READ (1,200) ISRC,ISQFT,ISILT,ISSE,IAVS,VMT,ITYPE,IPGRID
              IF(IPGRID.LT.37) GO TO 8
              GO TO 10
        9     READ (1,200,END=998) ISRC,ISQFT,ISILT,ISSE,IAVS,VMT,
         *    ITYPE,IGRID
      200     FORMAT (I1,I9,3I2,F10.2,I2,I3)
              IF (IGRID.NE.IPGRID) GO TO 46
       10     IF (ISRC.EQ.1) GO TO 20
              IF (ISRC.EQ.2) GO TO 25
              IF (ISRC.EQ.3) GO TO 30
              IF (ISRC.EQ.4) GO TO 35
              IF (ISRC.EQ.5) GO TO 38
              IF (ISRC.EQ.6) GO TO 45
              IF (ISRC.NE.7) STOP ' NO. SOURCES EXCEEDS 7'
C
C             RAILROADS
C             EF = 0.60*0.81*SILT:12.*(AVEVS/30.)*(1.-(112./365.))*0.10*VMT
C
              I7 = I7 + 1
              IF (VMT.NE.0) GO TO 15
              RR2 = 0.4042*(IAVS/30.)+RR2
              KAVS(7,I7) = IAVS
              GO TO 9
       15     RR1 = 0.4042*(IAVS/30.)*VMT+RR1
              KAVS(7,I7) = IAVS
              SVMT(7,I7) = VMT
              GO TO 9
C
C             PAVED ROADS
C             EMISS = 0.45*(SILT:12./10.)*(17.7/5000.)*(1.5/3.)*VMT*1000.
C
       20     I1 = I1 + 1
              PR = 0.9558*VMT + PR
              SVMT(1,I1) = VMT
              GO TO 9
C
C             GRAVEL ROADS
C             EF = 0.60*0.81*SILT:12.0*(AVS/30.)*(1.-(112./365.))*VMT
C
       25     I2 = I2 + 1
              KAVS(2,I2) = IAVS
```

```
              SVMT(2,I2) = VMT


      26      GR = 1475.496*((AVS/30.)*VMT/365. + GR
              GO TO 9
C
C             DIRT ROADS
C             EMISS = 0.60*0.81*SILT*(AVS/30.)*253./365.*VMT
C
      30      I3 = I3 + 1
              KSILT(3,I3) = ISILT
              KAVS(3,I3) = IAVS
              SVMT(3,I3) = VMT


      32      DR = 0.60*204.94458*ISILT*(IAVS/30.)*VMT/365. + DR
              GO TO 9
C
C             CONSTRUCTION SITES
C             EF = 14.4*ACRES*2000./365.
C
      35      ACRES = 0.00002296*ISQFT/3.
              I4 = I4+1
              SACRES(4,I4) = ACRES
              CS = ACRES*14.4*2000./365. + CS
              GO TO 9
C
C             AGGREGATE STORAGE PILES
C             EMISS = 0.33/(PE/100)**2*100000./365.
C
      38      I5 = I5 + 1
              IF (IGRID.NE.68.AND.IGRID.NE.78) GO TO 39
              IF (ITYPE.NE.30) GO TO 43
              AMTMAT = 84362.5
              GO TO 41
      39      IF (IGRID.NE.76) GO TO 40
              IF (ITYPE.NE.30) GO TO 43
              AMTMAT = 33945.0
              GO TO 41
      40      IF (IGRID.NE.97) GO TO 43
              IF (ITYPE.NE.25.AND.ITYPE.NE.30) GO TO 43
              IF (ITYPE.EQ.25) AMTMAT=6789000.0
              IF (ITYPE.EQ.30) AMTMAT=848625.0
      41      SP(I5) = 0.00014146*AMTMAT*2000./365.
              GO TO 44
      43      SP(I) = 14.116*2000./365.
      14      KTYPE(5,I5) = ITYPE
              SUMS = SUMS + SP(I5)
              GO TO 9
C
C             WIND EROSION
C             EF = 3400.*((SSE/50.)*(SILT/15.)*(21.4/25.))/(PE/50.)**2
C            *ACRES/365.
C
      45      I6 = I6+1
              ACRES = 0.00002296*ISQFT
```

```
              WE = 3400.*(((ISSE/50.)*(ISILT/15.)*(0.856))/1.6656)*
            *  ACRES/365. + WE
              KSSE(6,I6) = ISSE
              KSILT(6,I6) = ISILT
              SACRES(6,I6) = ACRES
              GO TO 9
C
C             COMPUTE TOTALS BY UNITS
C
        46    SUM1 = SUM1 + PR
              SUM2 = SUM2 + GR
              SUM3 = SUM3 + DR
              SUM4 = SUM4 + CS
              SUM6 = SUM6 + WF
              SUM7 = SUM7 + RR1
              SPSUM = 0.0
              DO 49 I=1,I5
        49    SPSUM = SPSUM + SP(I)
              TOTAL1 = PR + GR + DR + CS + SPSUM + WF + RR1
              TOT1 = TOT1 + TOTAL1
C
C             START WRITE STATEMENTS FOR INPUT PARAMETERS
C
              ICW = 0
              DO 66 M=1,NC
              IF (ICW.EQ.0) GO TO 51
              WRITE (6,301) IPGRID
       301    FORMAT ('+',I3/)
              IC6 = IC6 + 1
              ICW = 0
        51    IF (SVMT(1,M).EQ.0) GO TO 55                         !PAVED ROADS
              WRITE (6,302) SVMT(1,M)
       302    FORMAT ('+',8X,F7.2)
              ICW = ICW + 1
        55    IF (KAVS(2,M).EQ.0) GO TO 56                         !GRAVEL ROADS
              WRITE (6,303) KAVS(2,M)
       303    FORMAT ('+',31X,I2)
              ICW = ICW + 1
        56    IF (SVMT(2,M).EQ.0) GO TO 57
              WRITE (6,304) SVMT(2,M)
       304    FORMAT ('+',19X,F7.2)
              ICW = ICW + 1
        57    IF (KSILT(3,M).EQ.0) GO TO 58                        !DIRT ROADS
              WRITE (6,305) KSILT(3,M)
       305    FORMAT ('+',42X,I2)
              ICW = ICW + 1
        58    IF (KAVS(3,M).EQ.0) GO TO 59
              WRITE (6,306) KAVS(3,M)
       306    FORMAT ('+',60X,I2)
              ICW = ICW + 1
        59    IF (SVMT(3,M).EQ.0) GO TO 60
              WRITE (6,307) SVMT(3,M)
       307    FORMAT ('+',19X,F7.2)
              ICW = ICW + 1
        60    IF (SACRES(1,M).EQ.0) GO TO 61                       !CONSTRUCTION SITES
              WRITE (6,308) SACRES(4,M)
```

```
309   FORMAT ('+',70X,F6.1)
      ICW = ICW + 1
 61   IF (KSSF(6,M).EQ.0) GO TO 62                     !WIND EROSION
      WRITE (6,309) KSSF(6,M)
309   FORMAT ('+',86X,I2)
      ICW = ICW + 1
 62   IF (KSILT(6,M).EQ.0) GO TO 63
      WRITE (6,310) KSILT(6,M)
310   FORMAT ('+',98X,I2)
      ICW = ICW + 1
 63   IF (SACRES(6,M).EQ.0) GO TO 64
      IF ((IPGRID.EQ.55.OR.IPGRID.EQ.64).AND.M.EQ.2) GO TO 632
      IF (IPGRID.EQ.49.AND.M.EQ.3) GO TO 632
      IF (IPGRID.EQ.97.AND.M.EQ.2) GO TO 632
      IF ((IPGRID.EQ.63.OR.IPGRID.EQ.76).AND.M.EQ.3) GO TO 633
      IF ((IPGRID.EQ.78.OR.IPGRID.EQ.97).AND.M.EQ.3) GO TO 633
      GO TO 635
632   WRITE (6,315) SACRES(6,M)
315   FORMAT ('+',104X,F6.1,1X,'C')
      ICW = ICW + 1
      GO TO 64
633   WRITE (6,316) SACRES(6,M)
316   FORMAT ('+',104X,F6.1,1X,'O')
      ICW = ICW + 1
      GO TO 64
635   WRITE (6,311) SACRES(6,M)
311   FORMAT ('+',104X,F6.1)
      ICW = ICW + 1
 64   IF (SVMT(7,M).EQ.0) GO TO 65                     !RAILROADS
      WRITE (6,312) SVMT(7,M)
312   FORMAT ('+',114X,F7.2)
      ICW = ICW + 1
 65   IF (KAVS(7,M).EQ.0) GO TO 66
      WRITE (6,313) KAVS(7,M)
313   FORMAT ('+',126X,I2)
      ICW = ICW + 1
 66   CONTINUE
      IF (IC6.GT.45) GO TO 96
C
C     WRITE OUTPUT PARAMETERS
C
 80   CALL XY(IPGRID,X,Y)
      IF (IPGRID.GE.38) GO TO 85
      WRITE (3,325) X,Y,IPGRID,PR,TOTALI
325   FORMAT (1X,F7.0,1X,F7.0,2X,I3,2X,F8.2,81X,F10.2)
      IC3 = IC3 + 1
      GO TO 87
 85   ENCODE (2,350,KTYPEA,ERR=1000) KTYPE(5,1)
350   FORMAT (I2)
      IF (KTYPE(5,1).EQ.0) KTYPEA=' '
      ENCODE (10,351,RR1A,ERR=1000) RR1
351   FORMAT (F10.2)
      ENCODE (7,352,RR2A,ERR=1000) RR2
352   FORMAT (F7.2)
      IF (RR1.GT.0..AND.RR2.EQ.0.) RR2A=' '
      IF (RR1.EQ.0..AND.RR2.GT.0.) RR1A=' '
```

```
0216              WRITE (3,400) X,Y,IPGRID,PR,GR,DR,CS,SP(1),KTYPEA,WE,
               *  RR1A,RR2A,TOTAL1
0217        400   FORMAT (1X,F7.0,1X,F7.0,2X,I3,2X,F8.2,2X,F9.2,2X,F10.2,2X,
               *  F8.2,2X,F7.2,2X,A2,3X,F8.2,2X,A10,2X,A7,3X,F10.2)
0218              IC3 = IC3 + 1
0219              GO TO 91
0220         86   IF (EOF.EQ.1) GO TO 999
0221              IF (IC3.GT.45) GO TO 99
          C
          C       INITIALIZE EVERYTHING TO ZERO FOR NEXT GRID
          C
0222         87   DO 88 J1=1,NC
0223         88   SP(J1) = 0.0
0224              TOTAL1 = 0.
0225              DO 90 J=1,NC
0226              DO 89 K=1,10
0227              KSILT(K,J)  = 0
0228              KTYPE(K,J)  = 0
0229              KSSE(K,J)   = 0
0230              KAVS(K,J) = 0
0231              SVMT(K,J)   = 0.
0232              SACRES(K,J) = 0.
0233         89   CONTINUE
0234         90   CONTINUE
0235              PR = 0.0
0236              GR = 0.0
0237              DR = 0.0
0238              CS = 0.0
0239              WE = 0.0
0240              RR1 = 0.0
0241              RR2 = 0.0
0242              I1 = 0
0243              I2 = 0
0244              I3 = 0
0245              I4 = 0
0246              I5 = 0
0247              I6 = 0
0248              I7 = 0
0249              IPGRID = IGRID
0250              GO TO 10
0251         91   DO 93 K=2,NC
0252              IF (KTYPE(5,K).EQ.0) GO TO 96
0253              IC3 = IC3 + 1
0254              IF (KTYPE(5,K).EQ.25.OR.KTYPE(5,K).EQ.30) GO TO 92
0255              WRITE (3,425) KTYPE(5,K)
0256        425   FORMAT (75X,I2)
0257              GO TO 93
0258         92   WRITE (3,450) SP(K),KTYPE(5,K)
0259        450   FORMAT (66X,F7.2,2X,I2)
0260         93   CONTINUE
0261              GO TO 86
0262         96   WRITE (6,500)
0263        500   FORMAT ('1',51X,'FUGITIVE SOURCE CHARACTERISTICS'//1X,
               *  '*****',4X,7('*'),4X,17('*'),5X,24('*'),5X,6('*'),5X,29('*'),
               *  4X,17('*')/1X,'GRID',5X,'PAVED',11X,'GRAVEL',20X,'DIRT',15X,
               *  'CONSTR',17X,'WIND',21X,'RAILROADS'/1X,'NO.',6X,'ROADS',11X,
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               *    'ROADS',21X,'ROADS',14X,'SITES',17X,'EROSION'/1X,'*****',4X,
               *    7('*'),4X,17('*'),5X,24('*'),5X,6('*'),5X,29('*'),4X,17('*')/
               *    9X,'THOUSND',6X,'VMT',5X,'VEHICLE',5X,'SILT',5X,'VMT',5X,
               *    'VEHICLE',6X,'AREA',9X,'SURFACE',6X,'SILT',4X,'AREA',7X,
               *    'VMT',5X,'VEHICLE'/11X,'VMT',6X,'PER DAY',4X,'SPEED',6X,
               *    '(%)',4X,'PER DAY',4X,'SPEED',6X,'(ACRE)',6X,'ERODIBILITY',
               *    4X,'(%)',4X,'(ACRE)',4X,'PER DAY',4X,'SPEED'/9X,'PER YR',
               *    16X,'(MPH)',24X,'(MPH)',17X,
               *    '(TON/ACRE/YR)',31X,'(MPH)'/1X,'*****',4X,7('*'),4X,7('*'),3X,
               *    7('*'),5X,'*****',3X,7('*'),3X,7('*'),5X,6('*'),5X,13('*'),
               *    3X,'*****',3X,6('*'),4X,7('*'),3X,7('*')/)
0264                 IC6 = 0
0265                GO TO 80
0266         99     WRITE (3,600)
0267        600     FORMAT ('1',46X,'FUGITIVE DUST EMISSION BY SOURCE TYPE'//1X,
               *    15('*'),2X,'****',1X,8('*'),2X,9('*'),2X,10('*'),2X,8('*'),
               *    2X,12('*'),2X,8('*'),2X,20('*'),2X,10('*')/1X,
               *    'MD. COORDINATES',2X,'GRID',2X,'PAVED',5X,'GRAVEL',7X,
               *    'DIRT',6X,'CONSTR',5X,'STORAGE',7X,'WIND',9X,'RAILROADS',10X,
               *    'TOTAL'/6X,'FEET',8X,'NO.',3X,'ROADS',5X,'ROADS',8X,'ROADS',
               *    5X,'SITES',7X,'PILES',6X,'EROSION'/1X,15('*'),2X,'****',1X,
               *    8('*'),2X,9('*'),2X,10('*'),2X,8('*'),2X,12('*'),2X,8('*'),
               *    2X,20('*'),2X,10('*')/4X,'X',7X,'Y',11X,'LB/DAY',4X,'LB/DAY',
               *    6X,'LB/DAY',5X,'LB/DAY',3X,'LB/DAY',2X,'TYPE',3X,'LB/DAY',
               *    5X,'LB/DAY',4X,'LB/VMT',6X,'LB/DAY'/1X,
               *    7('*'),1X,7('*'),2X,'****',1X,8('*'),2X,9('*'),2X,10('*'),2X,
               *    8('*'),2X,7('*'),1X,4('*'),2X,8('*'),2X,10('*'),1X,9('*'),
               *    2X,10('*')/)
0268                IC3 = 0
0269                GO TO 87
0270        998     EOF = 1
0271                GO TO 46
0272        999     WRITE (3,660) SUM1,SUM2,SUM3,SUM4,SUM5,SUM6,SUM7,TOT1
0273        660     FORMAT (//' TOTAL',17X,F8.2,2X,F9.2,2X,F10.2,2X,F8.2,
               *    2X,F7.2,7X,F8.2,2X,F10.2,12X,F10.2)
0274                WRITE (3,700)
0275        700     FORMAT ('1','TYPE OF MATERIAL IN STORAGE PILES'//
               *    9X,'20  FINE MATERIAL'/9X,'21  COARSE MATERIAL'/
               *    9X,'22  DIRT'/9X,'23  GRAVEL'/9X,'24  SAND'/9X,'25  COAL'/
               *    9X,'26  OYSTER DUST'/9X,'27  MANGANESE ORE'/
               *    9X,'28  IRON ORE'/9X,'29  TRASH'/9X,'30  ORE PILES'/
               *    9X,'31  CONCRETE'/9X,'32  STONE'/9X,'33  METAL'/
               *    9X,'34  UNKNOWN'/9X,'35  ROAD SALT'/9X,'36  CHROME ORE'/
               *    9X,'37  FERROCHROME ORE'/9X,'38  FERROMANGANESE ORE'/
               *    9X,'39  BATTERYMANGANESE ORE'/9X,'40  SANDBLASTING GRIT'/
               *    9X,'41  CINDER BLOCKS')
0276                WRITE (3,800)
0277        800     FORMAT ('0EACH GRID IS ONE SQUARE MILE.  GRIDS 1 THROUGH',
               *    ' 120 MAKE UP BALTIMORE CITY.  THE BAQNC SURVEY WITHIN',
               *    ' BALTIMORE CITY COVERS'/' ONLY GRIDS 38-40, 43-50, 53-60,',
               *    ' 63-70, 73-80, 84-88, 90, 96-98, 106-109, AND 117-120 AS',
               *    ' CONTAINED ON THE CITY OF'/' BALTIMORE, DEPT. OF PUBLIC',
               *    ' WORKS, BUREAU OF ENGINEERING INDEX MAP.  THE MARYLAND',
               *    ' COORDINATES ARE TAKEN AT THE CENTER OF EACH GRID.'//
               *    ' THE PAVED ROAD EMISSIONS ARE BASED ON 1975 REGIONAL',
               *    ' PLANNING COUNCIL ESTIMATES OF AVERAGE WEEKDAY VEHICLE-',
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                *  'MILES-OF-TRAVEL (VMT)'/' WHICH INCLUDES AUTO TRAVEL ON',
                *  ' FREEWAYS AND ARTERIAL ROADS.  TRUCK TRAVEL, INTRA-RPD',
                *  ' (REGIONAL PLANNING DISTRICT) TRAVEL,'/' AND OTHER TRAVEL',
                *  ' ON LOCAL AND COLLECTOR STREETS ARE NOT INCLUDED.')
0278               WRITE (3,805)
0279       805     FORMAT ('OTHE RAILROAD EMISSIONS ARE BASED ON 1/10 OF THE',
                *  ' EMISSIONS PRODUCED BY THE GRAVEL ROAD EQUATION.'/
                *  ' FOR THE MAJOR RAILROAD SATELLITE YARDS LISTED BELOW,',
                *  ' A SILT CONTENT OF 30% AND AN ERODIBILITY OF 50 TONS/',
                *  'ACRE/YR IS ASSUMED'/' IN THE WIND EROSION EQUATION FOR BOTH',
                *  ' EXPOSED COAL AND ORE.  WHEN NO RAILROAD VMT ARE AVAILABLE',
                *  ' JUST THE APPROPRIATE EMISSION'/' FACTOR IS PRINTED.',
                *  '  ALL RAILROAD EMISSIONS (LB/DAY) ARE DUE TO THE MAJOR',
                *  ' SATELLITE YARDS ONLY.  THERE MAY BE OTHER RAILROAD TRACKS'/
                *  ' IN THE SAME GRID THAT WEREN''T INCLUDED IN THE EMISSION',
                *  ' ESTIMATE.  THE MAJOR RAILROAD SATELLITE YARD VMT ARE',
                *  ' CALCULATED BASED ON'/' INFORMATION FURNISHED BY THE',
                *  ' RAILROAD COMPANIES.')
0280               WRITE (3,900)
0281       900     FORMAT ('OGRID NO.',2X,'SATELLITE YARD'//4X,
                *  '49',5X,'BAYVIEW'/2X,'55, 64   MT. CLARE'/2X,'59, 60    ',
                *  'ORANGEVILLE CONRAIL'/2X,'67, 77   LOCUST POINT'/2X,
                *  '68, 78   CANTON YARD'/4X,'76',5X,'PORT COVINGTON'/
                *  4X,'97',5X,'CURTIS BAY'///' ALL FUGITIVE EMISSION',
                *  ' EQUATIONS EXCEPT THE DIRT ROADS EQUATION, ARE FOR',
                *  ' PARTICLES WITH AN AERODYNAMIC DIAMETER <30 MICRONS.'/
                *  ' THE DIRT ROAD EQUATION IS FOR PARTICLES WITH AN',
                *  ' AERODYNAMIC DIAMETER <100 MICRONS.'//' FOR GRID NUMBERS',
                *  ' 68, 76, 78,',
                *  ' AND 97 ACTUAL THROUGHPUT RATES WERE USED FOR STORAGE PILES',
                *  ' INSTEAD OF THE OTHERWISE ASSUMED'/' 100,000 TONS/YEAR',
                *  ' THROUGHPUT RATE.'//' THE DIRT AND GRAVEL ROAD VMT ARE',
                *  ' CALCULATED TO INCLUDE DIRT AND GRAVEL PARKING LOTS, AND',
                *  ' ARE BASED ON THE BAQNC SURVEY'/' INFORMATION.',
                *  '  FOR UNPAVED ROAD AND PARKING LOT VEHICLE SPEEDS <30',
                *  ' MILES/HOUR, THE AVERAGE VEHICLE SPEED IN THE UNPAVED',
                *  ' ROAD'/' EQUATION IS SQUARED.  FOR VEHICLE SPEEDS > OR =',
                *  ' 30 MILES/HOUR, THE AVERAGE VEHICLE SPEED IS NOT SQUARED.',
                *  ' ALL OTHER INPUT'/' INFORMATION EXCEPT SOIL SILT CONTENTS',
                *  ' AND ERODIBILITIES WAS FURNISHED BY THE BAQNC SURVEY.'//
                *  ' FOR OTHER INFORMATION PLEASE SEE FINAL REPORT.')
0282               WRITE (6,960)
0283       960     FORMAT ('1THE 1975 REGIONAL PLANNING COUNCIL ESTIMATES OF',
                *  ' AVERAGE WEEKDAY VEHICLE-MILES-OF-TRAVEL (VMT) FOR',
                *  ' PAVED ROADS INCLUDE'/' AUTO TRAVEL ON FREEWAYS',
                *  ' AND ARTERIAL ROADS.  TRUCK TRAVEL, INTRA-RPD (REGIONAL',
                *  ' PLANNING DISTRICT) TRAVEL, AND OTHER TRAVEL ON'/' LOCAL',
                *  ' AND COLLECTOR STREETS ARE NOT INCLUDED.'//' A 12% SILT',
                *  ' CONTENT IS ASSUMED FOR PAVED ROADS, GRAVEL ROADS, AND',
                *  ' RAILROAD BEDS.  A 1-1/2 TON AVERAGE VEHICLE WEIGHT IS',
                *  ' ASSUMED'/' FOR PAVED ROADS.  THE SURFACE DUST LOADING ON',
                *  ' TRAVELED PORTION OF PAVED ROAD IS ASSUMED TO BE 17.7',
                *  ' LB/MILE.  112 DAYS OF THE'/' YEAR ARE ASSUMED TO BE WET',
                *  ' IN BALTIMORE.'//' THORNTHWAITE''S PRECIPITATION-',
                *  'EVAPORATION INDEX (PE) FOR BALTIMORE IS 108.'//' THE %',
                *  ' TIME THAT THE SURFACE WIND SPEED EXCEEDS 12 MILES PER',
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            * ' HOUR IS 21.4 FOR BALTIMORE.'//' THE LETTERS "C" AND "O"',
            * ' ARE USED TO INDICATE WIND EROSION FOR COAL AND ORE',
            * ' SURFACES RESPECTIVELY.'//
            * ' ALL INPUT INFORMATION EXCEPT SURFACE SOIL SILT AND',
            * ' ERODIBILITY CONTENTS, AND RAILROAD VMT WERE FURNISHED BY',
            * ' THE BAONC SURVEY.'/' FOR OTHER INFORMATION SEE THE FINAL',
            * ' REPORT, AND THE NOTES ON THE OUTPUT SHEET.')
              CLOSE (UNIT=1,DISPOSE='SAVE')
              CLOSE (UNIT=2)
              STOP
       1000   STOP 'ERROR DURING ENCODE'
              END


              SUBROUTINE XY(NUM,X,Y)
         10   READ (2,100,END=999) NO,X,Y
        100   FORMAT (I3,2F6.0)
              IF (NO.EQ.NUM) RETURN
              IF (NO.LT.NUM) GO TO 10
              TYPE 200,NO,X,Y,NUM
        200   FORMAT ('ERROR MATCHING GRIDS:'/1X,'NO: ',I3,3X,'X: ',
            * F6.0,3X,'Y: ',F6.0,3X,'NUM: ',I3)
              STOP 'ERROR MATCHING GRID NUMBERS'
        999   RETURN
              END
```

```
C
C       BALTIMORE AND ANNE ARUNDEL COUNTIES
C
C       THIS PROGRAM IS SET UP TO READ IN VARIOUS PARAMETERS FOR
C       UP TO 7 DIFFERENT SOURCES, CALCULATE EMISSIONS, THEN PRINT
C       OUT INPUT INFO, EMISSIONS, AND TOTAL EMISSIONS BY UNIT.
C
C       VARIABLES:
C       SOURCE:  EMISSION SOURCE TYPE
C       SQFT  :  SQUARE FOOTAGE
C       SILT  :  % SILT
C       SSE   :  SURFACE SOIL ERODIBILITY
C       AVS   :  AVERAGE VEHICLE SPEED
C       VMT   :  VEHICLE MILES TRAVELLED
C       TYPE  :  MATERIAL TYPE
C       GRID  :  GRID NUMBER (1-120)
C       ACRES :  NO. ACRES CONVERTED FROM SQFT
C       TOTAL1:  LB/DAY
C       NC    :  NUMBER OF CARDS PER SOURCE TYPE
C
        INTEGER*4 ISQFT
        DIMENSION SVMT(10,6),SACRES(10,6),KSILT(10,6),
     *  KTYPE(10,6),KSSE(10,6),KAVS(10,6)
        NC = 6
        IC6 = 0
        IC3 = 0
C       I1 = 0
        I2 = 0
        I3 = 0
        I4 = 0
        I5 = 0
        I6 = 0
        I7 = 0
        TOT1 = 0.0
C       SUM1 = 0.0
        SUM2 = 0.0
        SUM3 = 0.0
        SUM4 = 0.0
        SUM5 = 0.0
        SUM6 = 0.0
C       SUM7 = 0.0
        TOTAL1 = 0.
C       PR = 0.0
        GR = 0.0
        DR = 0.0
        CS = 0.0
        SP = 0.0
        WF = 0.0
        RR = 0.0
        DO 7 J=1,NC
        DO 6 K=1,10
        KSILT(K,J) = 0
        KTYPE(K,J) = 0
        KSSE(K,J)  = 0
        KAVS(K,J)= 0
        SVMT(K,J)  = 0.
        SACRES(K,J)= 0.
      6 CONTINUE
      7 CONTINUE
        EOF = 0
        OPEN (UNIT=1,NAME='DB1:EMISS1.SRT',TYPE='OLD',READONLY)
        I[illegible]00
```

```
      ACCEPT *,NS
      IF (NS.GT.7) STOP ' NUMBER SOURCES EXCEED LIMIT OF 7'
      WRITE (6,500)
      WRITE (3,600)
      READ (1,200) ISRC,ISQFT,ISILT,ISSE,IAVS,VMT,ITYPE,
     * IPXMD,IPYMD
      GO TO 10
    9 READ (1,200,END=998) ISRC,ISQFT,ISILT,ISSE,IAVS,VMT,
     * ITYPE,IXMD,IYMD
  200 FORMAT (I1,I9,I2,I3,I2,F10.2,I2,2I3)
      IF (IXMD.NE.IPXMD.OR.IYMD.NE.IPYMD) GO TO 46
   10 IF (ISRC.EQ.1) GO TO 9
      IF (ISRC.EQ.2) GO TO 25
      IF (ISRC.EQ.3) GO TO 30
      IF (ISRC.EQ.4) GO TO 35
      IF (ISRC.EQ.5) GO TO 38
      IF (ISRC.EQ.6) GO TO 45
      IF (ISRC.NE.7) STOP ' NO. SOURCE EXCEEDS 7'
C
C     RAILROADS
C     EF = 0.60*0.81*SILT:12.*(AVEVS/30.)*(1.-(112./365.))*0.10*VMT
C
      I7 = I7 + 1
      RR = 0.4042*(IAVS/30.)
      KAVS(7,I7) = IAVS
      GO TO 9
C
C     PAVED ROADS
C     EMISS = 0.45*(SILT:12./10.)*(17.7/5000.)*(1.5/3.)*VMT*1000./365.
C
C  20 I1 = I1 + 1
C     PR = 0.9558*VMT/365. + PR
C     SVMT(1,I1) = VMT
C     GO TO 9
C
C     GRAVEL ROADS
C     EF = 0.60*0.81*SILT:12.0*(AVS/30.)*(1.-(112./365.))*VMT
C
   25 I2 = I2 + 1
      KAVS(2,I2) = IAVS
      SVMT(2,I2) = VMT


   26 GR = 1475.496*(IAVS/30.)*VMT/365. + GR
      GO TO 9
C
C     DIRT ROADS
C     EMISS = 0.60*0.81*SILT*(AVS/30.)*253./365.*VMT
C
   30 I3 = I3 + 1
      KSILT(3,I3) = ISILT
      KAVS(3,I3) = IAVS
      SVMT(3,I3) = VMT


   32 DR = 0.60*204.94458*ISILT*(IAVS/30.)*VMT/365. + DR
      GO TO 9
C
C     CONSTRUCTION SITES
C     EF = 14.4*ACRES*2000./365.
C
   35 ACRES = 0.00002296*ISQFT/3.
      I4 = I4+1
      SACRES(4,I4) = ACRES
      CS = ACRES*14.4*2000./365. + CS
```

```
C
C     AGGREGATE STORAGE PILES
C     EMISS = 0.33/(PE/100)**2*100000./365.
C
  38  I5 = I5 + 1
  43  SP = 14.146*2000./365.
  44  KTYPE(5,I5) = ITYPE
      GO TO 9
C
C     WIND EROSION
C     EF = 3400.*((SSE/50.)*(SILT/15.)*(21.4/25.))/(PE/50.)**2
C          *ACRES/365.
C
  45  I6 = I6+1
      ACRES = 0.00002296*ISQFT
      WE = 3400.*(((ISSE/50.)*(ISILT/15.)*(0.856))/4.6656)*
     * ACRES/365. + WE
      KSSE(6,I6) = ISSE
      KSILT(6,I6) = ISILT
      SACRES(6,I6) = ACRES
      GO TO 9
C
C     COMPUTE TOTALS BY UNITS
C
  46  SUM1 = SUM1 + PR
  46  SUM2 = SUM2 + GR
      SUM3 = SUM3 + DR
      SUM4 = SUM4 + CS
      SUM5 = SUM5 + SP
      SUM6 = SUM6 + WF
      SUM7 = SUM7 + RR
      TOTAL1 = PR + GR + DR + CS + SP + WE
      TOT1 = TOT1 + TOTAL1
C
C     START WRITE STATEMENTS FOR INPUT PARAMETERS
C
      ICW = 0
      DO 66 M=1,NC
      IF (ICW.EQ.0) GO TO 55
      WRITE (6,301) IPXMD,IPYMD
 301  FORMAT ('+',8X,I3,3X,I3/)
      IC6 = IC6 + 1
      ICW = 0
  51  IF (SVMT(1,M).EQ.0) GO TO 55                      !PAVED ROADS
      WRITE (6,302) SVMT(1,M)
 302  FORMAT ('+',12X,F7.2)
      ICW = ICW + 1
  55  IF (KAVS(2,M).EQ.0) GO TO 56                      !GRAVEL ROADS
      WRITE (6,303) KAVS(2,M)
 303  FORMAT ('+',34X,I2)
      ICW = ICW + 1
  56  IF (SVMT(2,M).EQ.0) GO TO 57
      WRITE (6,304) SVMT(2,M)
 304  FORMAT ('+',22X,F7.2)
      ICW = ICW + 1
  57  IF (KSILT(3,M).EQ.0) GO TO 58                     !DIRT ROADS
      WRITE (6,305) KSILT(3,M)
 305  FORMAT ('+',44X,I2)
      ICW = ICW + 1
  58  IF (KAVS(3,M).EQ.0) GO TO 59
      WRITE (6,306) KAVS(3,M)
 306  FORMAT ('+',62X,I2)
      ICW = ICW + 1
  59  IF (SVMT(3,M).EQ.0) GO TO 60
        (6    ) S    ,M)
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```
      ICW = ICW + 1
 60   IF (SACRES(4,M).EQ.0) GO TO 61                    !CONSTRUCTION SITES
      WRITE (6,308) SACRES(4,M)
308   FORMAT ('+',71X,F6.1)
      ICW = ICW + 1
 61   IF (KSSE(6,M).EQ.0) GO TO 62                      !WIND EROSION
      WRITE (6,309) KSSE(6,M)
309   FORMAT ('+',86X,I3)
      ICW = ICW + 1
 62   IF (KSILT(6,M).EQ.0) GO TO 63
      WRITE (6,310) KSILT(6,M)
310   FORMAT ('+',98X,I2)
      ICW = ICW + 1
 63   IF (SACRES(6,M).EQ.0) GO TO 65
      WRITE (6,311) SACRES(6,M)
311   FORMAT ('+',104X,F6.1)
      ICW = ICW + 1
 64   IF (SVMT(7,M).EQ.0) GO TO 65                      !RAILROADS
      WRITE (6,312) SVMT(7,M)
312   FORMAT ('+',114X,F7.2)
      ICW = ICW + 1
 65   IF (KAVS(7,M).EQ.0) GO TO 66
      WRITE (6,313) KAVS(7,M)
313   FORMAT ('+',117X,I2)
      ICW = ICW + 1
 66   CONTINUE
      IF (IC6.GT.45) GO TO 96

      WRITE OUTPUT PARAMETERS

 80   X1 = IPXMD * 1000.
      Y1 = IPYMD * 1000.
      X  = 0.305297 * ((X1*0.99851) + (Y1*0.0021799) + 272532.)
      Y  = 0.305297 * ((Y1*0.99851) - (X1*0.0021799) + 13720373.)
      XUTM = X/1000.
      YUTM = Y/1000.
      IXUTM = IFIX(XUTM)
      IYUTM = IFIX(YUTM)
      ENCODE (2,350,KTYPEA,ERR=1000) KTYPE(5,1)
350   FORMAT (I2)
      IF (KTYPE(5,1).EQ.0) KTYPEA=' '
      WRITE (3,400) IPXMD,IPYMD,IXUTM,IYUTM,GR,DR,CS,SP,KTYPEA,
     * WE,RR,TOTAL1
400   FORMAT (6X,I3,2X,I3,4X,I3,2X,I4,3X,F9.2,3X,F10.2,
     * 3X,F8.2,3X,F7.2,3X,A2,5X,F8.2,4X,F7.2,5X,F10.2)
      IC3 = IC3 + 1
      GO TO 91
 86   IF (EOF.EQ.1) GO TO 999
      IF (IC3.GT.45) GO TO 99

      INITIALIZE EVERYTHING TO ZERO FOR NEXT GRID

 87   TOTAL1 = 0.
      DO 90 J=1,NC
      DO 89 K=1,10
      KSILT(K,J)  = 0
      KTYPE(K,J)  = 0
      KSSE(K,J)   = 0
      KAVS(K,J) = 0
      SVMT(K,J)   = 0.
      SACRES(K,J) = 0.
 89   CONTINUE
 90   CONTINUE
      PR = 0.0
      GR = 0.0
```

```
      ZS = 0.0
      SP = 0.0
      WF = 0.0
      RR = 0.0
      I1 = 0
      I2 = 0
      I3 = 0
      I4 = 0
      I5 = 0
      I6 = 0
      I7 = 0
      IPXMD = IXMD
      IPYMD = IYMD
      GO TO 10
 91   DO 93 K=2,NC
      IF (KTYPE(5,K).EQ.0) GO TO 86
      IC3 = IC3 + 1
      WRITE (3,425) KTYPE(5,K)
425   FORMAT (76X,I2)
 93   CONTINUE
      GO TO 86
 96   WRITE (6,500)
500   FORMAT ('1',50X,'FUGITIVE SOURCE CHARACTERISTICS'//8X,
     * 11('*'),4X,17('*'),4X,24('*'),4X,6('*'),4X,29('*'),
     * 4X,9('*')/9X,'MARYLAND',12X,'GRAVEL',19X,'DIRT',
     * 14X,'CONSTR',16X,'WIND',17X,'RAILROADS'/8X,'COORDINATES',10X,
     * 'ROADS',20X,'ROADS',13X,'SITES',16X,'EROSION'/
     * 8X,11('*'),4X,17('*'),4X,24('*'),4X,6('*'),4X,29('*'),
     * 4X,9('*')/9X,'THOUSANDS',7X,'VMT',5X,'VEHICLE',
     * 4X,'SILT',5X,'VMT',5X,'VEHICLE',5X,'AREA',8X,'SURFACE',6X,
     * 'SILT',4X,'AREA',6X,'VEHICLE'/10X,'OF FEET',
     * 6X,'PER DAY',4X,'SPEED',5X,'(%)',4X,'PER DAY',4X,'SPEED',
     * 5X,'(ACRE)',5X,'ERODIBILITY',4X,'(%)',4X,'(ACRE)',
     * 6X,'SPEED'/10X,'X',5X,'Y',17X,'(MPH)',
     * 23X,'(MPH)',15X,'(TON/ACRE/YR)',22X,'(MPH)'/8X,'****',3X,
     * '****',4X,7('*'),3X,7('*'),4X,'****',3X,7('*'),3X,
     * 7('*'),4X,6('*'),4X,13('*'),3X,'****',3X,6('*'),4X,9('*')/)
      IC6 = 0
      GO TO 80
 99   WRITE (3,600)
600   FORMAT ('1',41X,'FUGITIVE DUST EMISSIONS BY SOURCE TYPE'//5X,
     * 22('*'),3X,9('*'),3X,10('*'),3X,8('*'),3X,13('*'),
     * 4X,8('*'),3X,9('*'),4X,10('*')/8X,'MD.',9X,'UTM',9X,
     * 'GRAVEL',7X,'DIRT',7X,'CONSTR',7X,'STORAGE',9X,
     * 'WIND',5X,'RAILROADS',6X,'TOTAL'/5X,'THOU. FT.',3X,'THOU. MET.',
     * 5X,'ROADS',8X,'ROADS',6X,'SITES',9X,'PILES',
     * 8X,'EROSION'/5X,22('*'),3X,9('*'),3X,10('*'),3X,
     * 8('*'),3X,13('*'),4X,8('*'),3X,9('*'),4X,10('*')/7X,'X',4X,
     * 'Y',6X,'X',4X,'Y',6X,'LB/DAY',7X,'LB/DAY',6X,
     * 'LB/DAY',4X,'LB/DAY',3X,'TYPE',5X,'LB/DAY',5X,
     * 'LB/VMT',8X,'LB/DAY'/5X,4('*'),1X,4('*'),3X,4('*'),1X,5('*'),3X,
     * 9('*'),3X,10('*'),3X,8('*'),3X,7('*'),2X,4('*'),4X,8('*'),
     * 3X,9('*'),4X,10('*')/)
      IC3 = 0
      GO TO 87
998   EOF = 1
      GO TO 46
999   WRITE (3,660) SUM2,SUM3,SUM4,SUM5,SUM6,TOT1
660   FORMAT (//' TOTAL',24X,F9.2,3X,F10.2,3X,F8.2,
     * 3X,F7.2,10X,F8.2,16X,F10.2)
      WRITE (3,700)
700   FORMAT ('1','TYPE OF MATERIAL IN STORAGE PILES'//
     * 9X,'20  FINE MATERIAL'/9X,'21  COARSE MATERIAL'/
     * 9X,'22  DIRT'/9X,'23  GRAVEL'/9X,'24  SAND'/9X,'25  COAL'/
     * [redacted]6 [redacted]R D[redacted]/9X,[redacted] MA[redacted] SF [redacted]/
```

```
     *    9X,'31  CONCRETE'/9X,'32  STONE'/9X,'33  METAL'/
     *    9X,'34  UNKNOWN'/9X,'35  ROAD SALT'/9X,'36  CHROME ORE'/
     *    9X,'37  FERROCHROME ORE'/9X,'38  FERROMANGANESE ORE'/
     *    9X,'39  BATTERYMANGANESE ORE'/9X,'40  SANDBLASTING GRIT'/
     *    9X,'41  CINDER BLOCKS')
          WRITE (3,800)
 800      FORMAT ('OTHE X AND Y CO-ORDINATES ARE FOR A COMBINATION OF',
     *    ' LOTS THAT HAVE THE SAME CO-ORDINATES, IN ANNE ARUNDEL AND',
     *    ' BALTIMORE COUNTIES,'/' JUST SOUTH OF BALTIMORE CITY.  THE',
     *    ' CO-ORDINATES ARE ROUGHLY FOR THE CENTER OF THE LOT.'//
     *    ' BECAUSE OF THE LACK OF DETAILED PAVED ROAD VMT FOR ANNE',
     *    ' ARUNDEL AND BALTIMORE COUNTIES AND BECAUSE THE PAVED ROAD',
     *    ' EMISSIONS'/' ARE GENERALLY NEGLIGIBLE, THEY ARE NOT',
     *    ' INCLUDED.')
          WRITE (3,805)
 805      FORMAT ('OTHE RAILROAD EMISSIONS ARE BASED ON 1/10 OF THE',
     *    ' EMISSIONS PRODUCED BY THE GRAVEL ROAD EQUATION.'/
     *    ' BECAUSE NO RAILROAD VMT ARE AVAILABLE, JUST THE',
     *    ' APPROPRIATE EMISSION FACTOR IS PRINTED.')
          WRITE (3,900)
 900      FORMAT ('OALL FUGITIVE EMISSION EQUATIONS',
     *    ' ARE FOR PARTICLES WITH AN AERODYNAMIC',
     *    ' DIAMETER <30 MICRONS.'//' A THROUGHPUT RATE',
     *    ' OF 100,000 TONS/YEAR IS ASSUMED FOR STOCKPILES.'//
     *    ' THE DIRT AND GRAVEL ROAD VMT ARE CALCULATED TO INCLUDE',
     *    ' DIRT AND GRAVEL PARKING LOTS, AND ARE',
     *    ' BASED ON THE BAQNC SURVEY'/' INFORMATION.  FOR UNPAVED ROAD',
     *    ' AND PARKING LOT VEHICLE SPEEDS <30 MILES/HOUR, THE AVERAGE',
     *    ' VEHICLE SPEED IN THE UNPAVED ROADS'/' EQUATION IS SQUARED.',
     *    '  FOR VEHICLE SPEEDS > OR = 30 MILES/HOUR, THE AVERAGE',
     *    ' VEHICLE SPEED IS NOT SQUARED.  ALL',
     *    ' OTHER INPUT'/' INFORMATION EXCEPT SOIL SILT CONTENTS',
     *    ' AND ERODIBILITIES WAS FURNISHED BY THE BAQNC SURVEY.'//
     *    ' FOR OTHER INFORMATION PLEASE SEE FINAL REPORT.')
          WRITE (6,960)
 960      FORMAT ('1THE CO-ORDINATES ARE FOR INDIVIDUAL LOTS THAT',
     *    ' WERE SURVEYED BY BAQNC IN ANNE ARUNDEL AND BALTIMORE',
     *    ' COUNTIES, AND ARE TAKEN'/' ROUGHLY AT THE CENTER OF EACH',
     *    ' LOT.  BECAUSE OF THE COMBINATION METHOD USED, THE NUMBER OF',
     *    ' LOTS WITH THE SAME CO-ORDINATES DO NOT'/' REPRESENT THE ACTUAL',
     *    ' NUMBER OF LOTS SURVEYED BY BAQNC.'//' A 12% SILT CONTENT',
     *    ' IS ASSUMED FOR GRAVEL ROADS AND RAILROAD BEDS.  112 DAYS OF',
     *    ' THE YEAR ARE ASSUMED TO BE WET IN BALTIMORE.'//
     *    ' THORNTHWAITE''S PRECIPITATION-',
     *    'EVAPORATION INDEX (PE) FOR BALTIMORE IS 108.'//' THE %',
     *    ' TIME THAT THE SURFACE WIND SPEED EXCEEDS 12 MILES PER',
     *    ' HOUR IS 21.4 FOR BALTIMORE.'//
     *    ' ALL INPUT INFORMATION EXCEPT SURFACE SOIL SILT AND',
     *    ' ERODIBILITY CONTENTS WERE FURNISHED BY',
     *    ' THE BAQNC SURVEY.'//' FOR OTHER INFORMATION SEE THE FINAL',
     *    ' REPORT, AND THE NOTES ON THE OUTPUT SHEET.')
          CLOSE (UNIT=1,DISPOSE='SAVE')
          STOP
 1000     STOP 'ERROR DURING ENCODE'
          END
```

```
C
C     THIS PROGRAM IS SET UP TO CONVERT MARYLAND CO-ORDINATES
C     TO UTM CO-ORDITNATES.
C
      OPEN (UNIT=1,NAME='SSCONV.DAT',TYPE='OLD',READONLY)
    6 WRITE (6,100)
  100 FORMAT ('1',9X,'CO-ORDINATE CONVERSION'//1X,'GRID NUMBER',3X,
     * 'X/Y',5X,'UTM',6X,'MARYLAND'/1X,11('*'),3X,'***',2(3X,8('*'))/)
      IC = 0
   10 READ (1,200,END=999) NUM,X1,Y1
  200 FORMAT (I3,2F6.0)
      X = 0.305297*((X1*0.99851)+(Y1*0.0021799)+272532.)
      Y = 0.305297*((Y1*0.99851)-(X1*0.0021799)+13720373.)
      WRITE (6,300) NUM,X,X1,Y,Y1
  300 FORMAT (4X,I3,9X,'X',4X,F8.0,3X,F8.0/16X,'Y',4X,F8.0,3X,F8.0/)
      IC = IC + 1
      IF (IC.GE.17) GO TO 6
      GO TO 10
  999 CLOSE (UNIT=1,DISPOSE='SAVE')
      STOP
      END
```

APPENDIX E

IIT RESEARCH INSTITUTE'S REPORT ON ANALYSIS OF HI-VOL FILTERS

by

Katherine Severin
and
Ronald G. Draftz

approved by

John Stockham

TABLE OF CONTENTS

1. INTRODUCTION

This is a final report presenting the results of high volume filter analysis to identify the types and sources of aerosols contributing to non-attainment of the Federal Total Suspended Particulates Standard at three sites in Baltimore, Maryland. IITRI's study was conducted under two subcontracts to GEOMET, Inc., who served as contractor to the Federal Environmental Protection Agency, Region III, and the State of Maryland for this study.

The results of both subcontracts have been merged and incorporated in this single report to provide continuity in assessing the data.

2. PURPOSE AND OVERVIEW OF THE STUDY

Several total suspended particulate (TSP) monitoring sites in Baltimore, Maryland currently exceed the primary Federal 24-hour particulate standard and are projected to continue causing violations of this standard through 1985. As part of a continuing effort to eliminate these violations the State of Maryland and the U.S. Environmental Protection Agency, Region III, enlisted the help of GEOMET, Inc. to perform a study of the sources contributing to TSP violations. GEOMET, Inc. subcontracted a part of their study to IIT Research Institute to perform microscopical and chemical analyses of selected high volume (hi-vol) filters.

The three sites selected for study are at or near Baltimore Harbor and are identified as:

Fire Department #22

Fort McHenry

Fire Department #10

These sites are thought to be representative of Baltimore's TSP non-attainment problem and also produced some of the highest TSP concentrations in the Baltimore area in 1976. A total of twenty one hi-vol filters were sent to IITRI, including three unidentified duplicate samples.

Polarized light microscopy was used as the primary analytical method to identify particle types and concentrations. Ancillary analytical techniques were used to corroborate the microscopical identifications on concentration measurements, as needed. These ancillary techniques included:

- chemical analysis for water soluble sulfates
- plasma emission spectroscopy for elemental analysis of lead and vanadium as tracers for vehicle exhausts and oil soot, respectively
- low temperature (plasma) ashing to determine the total organic content
- scanning electron, x-ray microanalysis to corroborate the identity of selected particles.

Plasma emission spectroscopy was also used for a quantitative broad survey of acid soluble elements in nine samples.

The results of these analyses were used by IITRI to independently identify generic sources and their contributions to TSP concentrations. The generic source assignment was conducted by IITRI without knowledge of the specific sources proximate to the sampling sites. These data can be coupled with meteorological and emissions inventory data to pinpoint specific stationary and fugitive dust sources.

Summary of Analytical Methods

The analytical methods used to identify the aerosols collected on high volume filters include polarized light microscopy, low temperature plasma ashing, plasma emission spectroscopy, scanning electron microscopy, and sulfate analysis. Details of the methods are given in subsequent sections.

Polarized light microscopy was used as the principal means of identifying aerosols. The concentration of each identified aerosol type (or group, such as minerals) was determined by performing particle size distributions and particle counts by aerosol type to compute the mass concentration per unit filter area. The mass concentration of each individual component was then summed with all other components and normalized to provide a weight percentage by component for each sample.

Low temperature plasma ashing was used to determine the total combustible components concentration of aerosols such as starch, pollens and carbonaceous vehicle exhausts. The residue after low temperature ashing then corresponded to the inorganic component concentrations such as pavement and soil minerals, fly ash, and slag. Thus, low temperature ashing served as a simple, independent method for measuring the concentrations of organic and inorganic aerosols, which generally originate from different sources.

Ammonium sulfate which originates from the reaction of atmospheric ammonia with sulfur oxides from fuel combustion, was determined by a separate analytical procedure. This separate analytical procedure was necessary because ammonium sulfate is often found buried in the filter matrix or at the filter bottom. Therefore, for heavily loaded filters, i.e., those with high TSP concentrations, the sulfate crystals are partially obscurred by other particles nesting on the filter surface. (In spite of this obscuration, polarized light microscopy can still reveal whether the sulfate concentrations are major, minor or trace by simply mounting a sample upside down.)

Lead and vanadium concentrations were analyzed by plasma emission spectroscopy (PES) to determine the contributions from auto exhuast and oil soot, respectively, from source coefficient factors. In addition, PES was used to determine boron, calcium, magnesium, zinc, silicon, copper, nickel, manganese, molybdenum, cobalt, aluminum, titanium, barium, chromium and iron concentrations in nine samples selected by the State of Maryland. These analyses were used to corroborate the microscopy results.

The same nine samples selected for PES analysis were also examined by scanning electron microscopy (SEM) with x-ray microanalysis of individual particles. These analyses also served as a corroborating technique for the particle identifications by polarized light microscopy.

3. SAMPLE ANALYSES AND RESULTS

Sample Preparation

Halves (8"x5") of eighteen standard hi-vol filters and three unknown filters were submitted for analysis. The sampling sites, dates, TSP concentrations and average wind speeds for these samples are shown in Table E-1. The TSP concentrations listed in parentheses

Table E-1. Hi-Vol Filter Data

Sampling Date	Day of Week	TSP Concentration, $\mu g/m^3$			Average Wind Speed, mph
		Fire Dept. #10	Fire Dept. #22	Fort McHenry	
6/9/77	Thursday	63	(NA)	59	9.6
6/21/77	Tuesday	(145)	60	(136)	10.5
7/15/77	Friday	221	149	(114)	5.6
8/2/77	Tuesday	(142)	(93)	154	6.2
9/19/77	Monday	(165)	108	(69)	5.8
9/25/77	Sunday	51	38	39	11.1
10/25/77	Tuesday	306	(NA)	118	3.9
11/24/77	Thursday	42	52	41	4.3
12/12/77	Monday	169	129	85	(NA)

NA - Not Available.

are for samples that were not submitted for analysis, but they are included for comparison.

Each hi-vol filter was opened in a class 100 cleanbench and visually examined for artifact contaminants such as paper fiber bundles or sample loss due to filter tears, raindrops or fingerprints. No contaminants or particle losses were seen on any filter. Each sample was also examined by stero-microscopy for uniformity of particle deposition. As usual, the folded filter showed an obvious increase in the concentration of large particles that had fallen into the crease during shipment. Some of the large particles had also fallen off the hi-vol filter into the envelope used to protect the filter during shipment. We did not determine the extent of large particle bias in the crease, but it appeared insignificant.

Each filter was cut with a stainless steel scalpel into a number of sections for analysis. The exact sizes for each analytical test will be described with each test. We presumed that areas of the various sections had mass loadings proportional to the total filter. This approach was favored over weighing the cut sections because it eliminated the need to recondition the filter for weighing and avoided the possible problem caused by filter fiber losses. These filter fiber losses might make a weighed section seem smaller than its true size.

Low Temperature Ashing Procedure

Precisely measured 6.35 cm x 3.81 cm sections were cut for low temperature ashing. The sections were dessicated for 24 hours, weighed, and then ashed for two hours in an LFE Model 310 asher. The sections were then redessicated and weighed to determine the loss due to oxidation of organics.

Each ashed filter strip was examined microscopically to confirm that ashing was complete. If it appeared that additional ashing was needed the sample was ashed for two more hours. Several filters were re-ashed but no additional weight loss occurred which confirmed that ashing was complete in two hours.

Low temperature plasma ashing (LTA) is usually accomplished at temperatures below 200°C and at a pressure of approximately 1 min of mercury. At these ashing conditions ammonium sulfate sublimes and contributes to the weight loss. Therefore, the ammonium sulfate content must be subtracted from the LTA weight loss to determine the organic content.

A slight weight increase can occur during LTA if samples contain metals or reduced metal oxides such as FeO or Fe_3O_4. These compounds will oxidize contributing a negligible to slight weight gain. In practice the weight gain is undetectable because only the surface oxidizes. The oxidized surface is non-volatile and acts as a barrier to complete oxidation. In addition, the reduced metal oxide content of most hi-vol samples is usually below five percent and often below one half percent. Therefore, the weight gain would be trivial even if the oxidation were complete. Since FeO, Fe_3O_4 and most alloys of iron are magnetic, it is fairly simple to estimate (or quantitate) whether a weight gain during LTA would be detectable.

Results of Low Temperature Ashing

Table E-2 shows the low temperature ash losses corrected for sulfate loss, for each sample.

The organic components contributing to the loss include:

Table E-2. Low Temperature Ash Losses

Date	Site	Total Organic Content(1)	
		Wt. Pct.	$\mu g/m^3$
6/9/77	Fire Dept. #10	20	13
6/9/77	Fort McHenry	21	12
6/21/77	Fire Dept. #22	20	12
7/15/77	Fire Dept. #10	16	35
7/15/77	Fire Dept. #22	24	36
8/2/77	Fort McHenry	50	77
9/19/77	Fire Dept. #22	20	22
9/25/77	Fire Dept. #10	3	2
9/25/77	Fire Dept. #22	10	4
9/25/77	Fort McHenry	1	0.4
10/25/77	Fire Dept. #10	10	31
10/25/77	Fort McHenry	30	35
11/24/77	Fire Dept #10	10	4
11/24/77	Fire Dept. #22	15	8
11/24/77	Fort McHenry	15	6
12/12/77	Fire Dept. #10	28	47
12/12/77	Fire Dept. #22	23	30
12/12/77	Fort McHenry	26	22

(1) Total Organic Content = (LTA Loss) - (H_2O soluble $SO_4^=$ [as $(NH_4)_2SO_4$]).

- carbonaceous tailpipe exhaust
- rubber tire fragments
- coal fragments
- oil soot
- cornstarch
- pollens , spores, conidia
- plant parts
- insect parts

Sulfate Analysis

The two principal forms of sulfates in the atmosphere are ammonium sulfate and sulfuric acid. If the sulfates are collected as sulfuric acid they will generally react with limestone particles from pavement aggregate to form calcium sulfate, or will react with ambient ammonia to form ammonium sulfate. The most abundant sulfate form found on hi-vol filters is ammonium sulfate.

Ammonium sulfate is hygroscopic and dissolves on hi-vol filters, and the droplets penetrate to the bottom of the filter where they evaporate leaving crystals of ammonium sulfate. Because these droplets containing sulfate may contact other particles on the filter, the sulfates may crystallize over the surface of the water insoluble particles. These transparent, colorless sulfate crystals coating opaque carbonaceous particles cannot be readily seen by optical microscopy. Therefore, sulfate is determined by a separate chemical procedure from a water or acid extract of a filter segment.

An exactly measured filter section, approximately 50 cm^2, is placed in a 150 ml acid washed beaker. To the beaker, 2 ml of 1:1 MNO_3 and 20 ml of deionized water is added. The beaker is covered with a watch glass and the sample heated to near dryness on a hot plate. (approximately 6 hours). An additional 4 ml of 1:1 MNO_3 and 40 ml of deionized water are added. The heating is repeated until a final v-lume of approximately 2 ml is achieved.

The resulting solution is diluted with a few milliliters of deionized water and filtered through Whatman 41 paper. The sample filter is agitated during the filtering and washing with a stirring rod. The filtered solutions are brought up to a final volume of 25 mls.

Sulfate concentrations are determined turbidimetrically The detection limit is approximately 0.1 $\mu g/cm^2$, while the sensitivity is 2 $\mu g/cm^2$.

The results of the sulfate analyses are shown in Table E-3 in weight percentage and in micrograms per cubic meter. The weight percentage values show the impact of sulfates on total TSP, while the concentrations in $\mu g/m^3$ indicate whether all the sampling sites have a similar or dissimilar exposure level due to remote or local sources, respectively.

Table E-3. Sulfate Concentrations

Sampling Date	Weight Percentage			Micrograms Per Cubic Meter		
	FD 10	FD 22	FT MH	FD 10	FD 22	FT MH
6/9/77	21	-	30	13	-	18
6/21/77	-	24	-	-	14	-
7/15/77	13	16	-	29	24	-
8/2/77	-	-	15	-	23	-
9/19/77	-	22	-	-	24	-
9/25/77	36	40	50	18	15	20
10/25/77	13	-	18	40	-	21
11/24/77	35	32	45	15	17	18
12/12/77	13	17	25	22	22	21

ELEMENTAL ANALYSIS

Elemental analyses were performed for several reasons:

- To corroborate the microscopical data
- To provide lead and vanadium concentrations so the total concentrations of carbonaceous auto exhaust and oil soot can be calculated
- To provide a broad elemental scan for the presence of unusual components.

Lead, vanadium, calcium, and iron were analyzed in each of the 18 known samples, as well as, the three, duplicate unknown samples. Lead and vanadium are somewhat unique elements that have been used as atmospheric tracers for auto exhaust and oil soot, respectively. These tracers are used with source coefficient factors to compute the concentration contribution from generic sources.

There are a few problems that affect the accuracy of the calculated source contributions when using source factors. The calculated source impact from autos presumes a fixed ratio of lead emissions to total particulate exhausts. However, the ratio of lead to carbonaceous exhaust particles depends on vehicle speed, idling time at intersections and leaded to unleaded fuel use ratios. These parameters can change the source coefficient factor by perhaps as much as 600 percent. However, in this study we can reasonably presume that a constant source coefficient factor for lead is adequate. We know from our microscopical analysis that there were no other significant sources of lead found in the samples.

The need for these lead and vanadium analyses is caused by the fact that submicrometer, opaque, particles such as those from auto and diesel exhaust and crushed oil soot are difficult to distinguish by optical microscopy. (It's important to emphasize that supermicrometer particles of oil soot are easily recognized by optical microscopy.) Scanning electron microscopy (SEM) could be (and has been) used to distinguish fine, carbonaceous particles, but a quantitative SEM procedure would be extremely time consuming. Therefore, elemental analysis is the simplest, adequate procedure to determine contributions from auto exhaust and oil burning. The carbonaceous auto exhaust content is 1.5 times the lead concentration. Oil soot is 39 times the vanadium content.

Calcium and iron concentrations were determined to corroborate the microscopical analysis for limestone and iron oxides. Unfortunately, the variation in blank values for calcium, and to a lessor extent iron, made these analyses of doubtful benefit for corroboration. If anything, it appears that elemental analysis for determining major source contributions on hi-vol filters may be futile due to the variable background values on the surface of unexposed filters, as revealed by analysis of "blank" filters.

Nine of the hi-vol filters were analyzed for 13 other elements to serve as a scanning method for other components. The same sample dissolution procedure that was used for the sulfate analysis, described above, was also used for elemental analyses. The metals were analyzed by plasma emission spectroscopy using a lithium buffer and a germanium internal standard.

Results for the elemental analysis are shown in Tables E-4 and E-5.

Table E-4. Elemental Results for Pb, V, Ca, and Fe

Sampling Date	Site	TSP, $\mu g m^{-3}$	Pb			V			Ca			Fe		
			$\mu g \cdot cm^{-2}$	$\mu g \cdot m^{-3}$	Wt. Pct.	$\mu g \cdot cm^{-2}$	$\mu g \cdot m^{-3}$	Wt. Pct.	$\mu g \cdot cm^{-2}$	$\mu g \cdot m^{-3}$	Wt. Pct.	$\mu g \cdot cm^{-2}$	$\mu g \cdot m^{-3}$	Wt. Pct.
6/9/77	FD 10	63	2.7	0.42	0.67	0.15	0.025	0.04	40	6.2	9.9	5.3	0.82	1.3
6/9/77	FD MH	59	1.5	0.31	0.52	0.24	0.047	0.08	28	5.7	9.7	4.0	0.83	1.4
6/21/77	FD 22	60	2.3	0.47	0.79	0.06	0.012	0.02	38	7.8	13	4.5	0.90	1.5
7/15/77	FD 10	221	7.8	1.14	0.52	0.63	0.090	0.04	66	9.7	4.4	19	2.9	1.3
7/15/77	FD 22	149	3.6	0.74	0.50	0.26	0.060	0.04	24	4.9	3.3	9.8	2.1	1.4
8/2/77	FT MH	154	2.1	0.42	0.27	0.15	0.030	0.02	57	11.4	7.4	5.8	1.2	0.76
9/19/77	FD 22	108	3.0	0.61	0.57	0.30	0.060	0.06	36	7.3	6.8	8.0	1.6	1.5
9/25/77	FD 10	51	1.6	0.24	0.46	0.20	0.030	0.06	50	7.3	14.4	5.0	0.71	1.4
9/25/77	FD 22	38	1.7	0.34	0.89	0.11	0.020	0.06	25	5.0	13.1	2.3	0.46	1.2
9/25/77	FT MH	39	1.2	0.25	0.64	0.41	0.090	0.22	34	11.3	29	3.7	0.78	2.0
10/25/77	FD 10	306	11	1.6	0.53	0.51	0.060	0.02	91	13.5	4.4	28	4.0	1.3
10/25/77	FT MH	118	4.6	0.90	0.76	0.23	0.050	0.04	56	11.0	9.3	13	2.6	2.2
11/24/77	FD 10	42	4.4	0.59	1.4	0.14	0.020	0.05	57	7.7	18.3	4.1	0.55	1.3
11/24/77	FD 22	52	3.3	0.67	1.3	0.12	0.020	0.05	50	10.2	19.6	3.5	0.73	1.4
11/24/77	FT MH	41	2.4	0.51	1.3	0.11	0.020	0.06	66	14.1	34.3	2.7	0.57	1.4
12/12/77	FD 10	169	5.7	0.79	0.4	0.43	0.070	0.04	72	10.0	5.9	17	2.4	1.4
12/12/77	FD 22	129	28	0.56	0.4	0.37	0.080	0.06	62	12.4	9.6	9.3	1.8	1.4
12/12/77	FT MH	85	2.6	0.51	0.6	0.42	0.090	0.10	49	9.7	11.4	6.8	1.4	1.6
Dup. A		154*	2.1	0.42	0.27	0.20	0.050	0.03	20	4.0	2.6	4.2	0.85	0.55
Dup. B		38*	1.7	0.34	0.89	0.16	0.030	0.08	18	3.6	9.4	1.9	0.38	1.0
Dup. C		306*	13	1.94	0.63	0.10	0.090	0.03	122	18.1	5.9	39	5.8	1.9
Blank 1			<0.02			<0.02			2.4			0.03		
Blank 2			0.23			<0.02			20			0.41		
Blank 3			<0.02			<0.02			30			0.61		

*Presumed value

Table E-5. Concentrations of Various Elements in Nine Hi-Vol Samples

Sampling Date	Site		TSP, gm^{-3}	Concentration in Micrograms per cm^2 *													
				Al	B	Mg	Si	Ba	Cd	Cr	Co	Cu	Mn	Mo	Ni	Ti	Zn
7/15/77	FD	10	221	19	4.2	37	1.8	0.53	0.23	1.3	<0.02	1.8	1.6	0.05	0.31	1.03	2.4
7/15/77	FD	22	119	13	3.0	9.6	8.2	0.18	<0.02	0.21	<0.02	0.46	0.56	0.05	0.12	0.35	1.3
9/25/77	FD	10	51	22	11	22	0.52	0.17	0.04	0.05	<0.02	1.6	0.23	<0.02	0.16	0.16	0.44
9/25/77	FD	22	38	14	5.3	10	0.14	0.11	<0.02	0.04	<0.02	0.49	0.10	<0.02	0.08	0.06	0.31
9/25/77	FI	MH	39	23	13	22	2.7	0.14	0.03	0.0[illegible]	<0.02	0.55	0.12	0.03	0.18	0.12	0.46
10/25/77	FD	10	306	22	3.2	119	1.8	0.58	0.07	1.6	0.03	3.9	3.8	0.02	0.49	3.0	1.6
12/12/77	FD	10	169	22	4.0	39	0.86	0.40	0.04	0.64	0.03	1.6	1.7	0.04	0.28	0.94	0.99
12/12/77	FD	22	129	22	9.9	21	0.91	0.32	0.16	0.38	<0.02	0.49	1.1	0.02	0.18	0.39	0.60
12/12/77	FI	MH	85	22	9.9	19	1.5	0.22	0.04	0.18	0.02	0.63	0.66	0.05	0.17	0.33	0.65
Blank 1				1.03	0.29	0.59	1.8	0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03
Blank 2				10	3.0		3										

Sampling Date	Site		Concentration in Micrograms per m^3 *													
			Al	B	Mg	Si	Ba	Cd	Cr	Co	Cu	Mn	Mo	Ni	Ti	Zn
7/15/77	FD	10	2.7	0.61	5.5	0.27	0.09	0.03	0.20	<0.002	0.27	0.24	0.007	0.04	0.15	0.35
7/15/77	FD	22	2.9	0.62	1.9	1.6	0.03	<0.004	0.04	<0.004	0.09	0.12	0.01	0.03	0.07	0.27
9/25/77	FD	10	3.2	1.6	3.2	0.08	0.03	0.006	0.005	<0.003	0.23	0.04	<0.003	0.03	0.03	0.07
9/25/77	FD	22	2.8	1.1	2.0	0.03	0.02	0.004	0.004	<0.004	0.10	0.02	<0.004	0.02	0.01	0.06
9/25/77	FI	MH	4.8	2.7	4.6	0.55	0.03	0.006	0.02	<0.004	0.11	0.02	0.006	0.04	0.02	0.10
10/25/77	FD	10	3.4	0.46	17.4	0.28	0.09	0.009	0.24	0.003	0.58	0.55	0.003	0.06	0.43	0.24
12/12/77	FD	10	3.0	0.56	5.4	0.12	0.05	0.005	0.08	0.003	0.22	0.21	0.005	0.03	0.14	0.14
12/12/77	FD	22	4.4	1.9	4.1	0.18	0.06	0.03	0.08	<0.004	0.10	0.22	0.004	0.04	0.08	0.12
12/12/77	FI	MH	4.3	2.0	3.7	0.30	0.04	0.008	0.03	0.004	0.13	0.13	0.009	0.03	0.07	0.13
Blank 1																
Blank 2																

* Blank value not subtracted

DISCUSSION OF THE ELEMENTAL DATA

Aluminum, silicon, calcium, magnesium and boron are the matrix elements of the glass fiber hi-vol filters. We presumed that some of these elements would be leached from the fibers during acid dissolution of the sample. We also presumed that the amount of these elements leached from the filters would be about the same so a blank could be subtracted. However, three different blanks run for calcium gave values of 2.4, 20 and 30 micrograms per cm^2. The 30 micrograms per cm^2 blank value exceeded the values for five samples.

In comparing these results with those run by another lab we learned that the glass fiber matrix elements can vary by a factor of 40. This variation in blank values makes it impossible to use the sample calcium values to verify the calcite content. The trace elements that are not glass matrix elements show reasonably consistent blanks that are appreciably lower than sample values. However, these are less important elements in determining the cause of high TSP concentrations.

4. MICROSCOPICAL ANALYSIS

Particle Identification

Particle properties readily observed by microscopic techniques are listed in Table E-6. Determination of most of these properties is usually accomplished by simple examination with a polarized light microscope. Since particles possess unique sets of physical and optical properties, determination of these properties usually results in the identification of the particle types. Succinct differences in individual particle properties at various levels allows distinction between particles of identical chemical composition but of different types of sources. Silicon dioxide is a good example of a compound which occurs in several distinct particle types. Cristobalite and quartz are forms of SiO_2 which are readily distinguished by optical microscopy due to their differences in refractive index and birefringence. While x-ray diffraction (xRD) would distinguish these particle types, the applicability of xRD to hi-vol filter analysis is extremely limited because a large sample size is needed. X-ray diffraction could not, however, distinguish between three other common silica forms -- beach sand, doundry sand and soil derived quartz. Morphological properties alone must be used to distinguish these silicas.

Table E-6. Microscopical Properties of Particles

Optical	Physical
Transparency	Size
Color	Shape
Refractive Index	Surface Texture
Birefringence	Magnetism
Reflectance	Solubility
Pleochroism	Melting Point
Fluorescence	Density

Particle types composed primarily of carbon are practically impossible to identify by any technique other than optical microscopy. Oil soot and coal fragments are primarily carbon but do have associated trace elements which can be used to help distinguish one from the other. However, the two types of particles are readily distinguished microscopically. Oil soot is hollow, opaque, black and spherical with a surface texture that ranges from dull and grainy to a lacy network of filaments. Coal particles, on the other hand, are black, angular fragments with smooth to dull, glistening surfaces. Biological particles -- pollens, spores, trichomes, insect parts, starch, etc. - are also composed primarily of carbon and would be included in a total organic carbon analysis of a hi-vol filter. Although these biological particles rarely exceed one percent of the total collected mass on an urban filter sample, the ability to distinguish this carbon particle type from others is especially important in the analysis of rural samples or when a source influence such as a granary is expected.

Just as the spectroscopist relies on libraries of reference spectra for the identification of unknown samples analyzed, the microscopist also relies on reference collections of particle data for identification of particle types. These reference collections include the microscopist's own previous experience, handbooks of optical properties (e.g., refractive indices, Michel-Levy birefringence charts, etc.), atlases of photomicrographs, and actual (particulate) source samples.

The specific bases for assigning particles to sources in this study will be described in later sections.

Sample Preparation

After surveying the hi-vol filter provided for analysis of uniformity of particle deposition, a triangular section measuring approximately 2 cm on each side was cut from the filter and immersed in a pool of immersion liquid on a glass slide. After the oil had soaked through to the front surface of the filter section, a cover slip was placed on top to complete the mount. The immersion liquid employed had a refractive index of 1.515. This liquid matched the refractive index of the glass fiber filter substrate, thereby rendering the filter transparent.

A second slide was prepared from each filter with AROCLOR 5442 as the mountant. A drop of heated AROCLOR 5442 was allowed to cool at the end of a glass rod until the drop became tacky. The adhesive drop was then lightly pressed against several areas of a dry hi-volume filter section until the top surface was loaded with particles. The AROCLOR and particles were then transferred to a clean glass slide by heating the glass rod until the AROCLOR liquified and dropped off onto the slide. A cover glass was added to complete the mount. AROCLOR has refractive index of 1.66 and thus allows viewing of particles which may be invisible in the 1.515 mounting medium. A third slide of the low temperature ash residue was also prepared for microscopy. The elimination of opaque, carbonaceous particles aided in performing size distribution measurements for small mineral particles.

Samples of roadbed materials which were submitted for analysis along with hi-vol filters were ground in a diamonite mortar and pestle before dispersing in 1.515 refractive index liquid on glass slides. Source and soil samples which also supplemented the hi-vol filters were not ground but gently disaggregated before mounting in 1.515 refractive index liquid on glass slides.

The mounted filter sections, AROCLOR slides, and source samples were analyzed by polarized transmitted light and oblique reflected light microscopy. Magnifications ranging from 62.5X through 625X were employed to view the particle types present.

Mineral Particles

Quantitative analysis by polarized light microscopy is a two step procedure. Particles are first identified as specific compounds such as quartz, calcite and hematite, or as generic types such as coal flyash, cornstarch, and rubber tire fragments. Then the individual particles are counted and sized to determine their areal mass concentration. The areal mass concentrations of all the components are summed and normalized to produce a weight percentage for each component.

Before presenting the results of the quantitative microscopical analysis, it is necessary to describe the individual components which comprise the samples. The components were essentially the same at all three sampling sites so that the particle descriptions are common for all samples.

The sample report format (see tables at end of Appendix E) identifies components of particle types by generic source with the exception of the minerals components. Minerals includes the components silicates, calcite, mica, clays and humus. The silicates include quartz (SiO_2) and feldspars (such as orthoclase, $KAlSi_3O_8$) which are principal constituents of rocks and soils. While the individual species in this component group can be distinguished microscopically, their optical and morphological characteristics are similar, especially for the feldspar minerals. These similarities, along with their likely common source, soil, led to the decision to combine them under one component category. Trace concentrations of other silicates such as augite and abvine are also grouped in the silicates component. Calcite ($CaCO_3$) is another common though minor constituent of soils but its main occurrence is as asphalt or concrete pavement aggregate. Calcite is the principal mineral of quarried limestone but aragonite ($CaCO_3$) and dolomite [$CaMg(CO_3)_2$] may also be present in small concentrations. The crushed crystals of these minerals are not easily distinguished by polarized light microscopy, so traces of dolomite and perhaps aragonite may be present in the calcite component.

The three principal mica species are biotite, muscovite and phlogapite which are potassium aluminosilicates. These silicates were grouped separately because the micas are so easily identified, even though their primary source is also soil.

Clays and humus are the final soil components listed under Minerals. The submicron clay particles are generally found as agglomerates and range in size from 1 μm to 10 μm. Discrete clay particles also coat the larger mineral grains in soil, but these clay particles contribute so little to the mass that they can be ignored. Humus is the organic matter in soil. Humus is predominantly decomposing plant fragments that appear as translucent, dark brown isotropic fragments, often coated with clay particles.

With the exception of calcite, all of the Mineral components are present in Baltimore's soil. Calcite was also found in the soil but appears to be present as a contaminant from the roadway pavement. This will be discussed in the later section on TSP source assignments.

Description of Quantitative Microscopy Procedure

The method for determining the weight percentages for specific particles in each hi-vol sample is based on a simple particle counting and sizing procedure. The mass of a specific particle type in a known area of filter (the microscopical field of view) is calculated from the particle size distribution and number concentration. The procedure is repeated for each type of particle in the sample so that the mass per unit filter area is determined for each particle. The weight percentage for a component is simply the mass per unit area for that component divided by the sum of the mass per unit area of all components.

The mass concentration for a component could be calculated directly as micrograms per cubic meter by merely scaling individual mass per unit area values to the total filter area and dividing by the total air volume sampled. This approach will work well when the particles concentrations are uniformly deposited over the filter. However, we know there is some loss of large particles that fall into the crease of the folded filter which could cause low values for certain components and a lack of mass balance with the total filter loading. Non-equivalent particle shapes could also cause under or over estimates of particle size for components becuase of their preferred orientation on the filter. Therefore, we elected to normalize data rather than calculate mass concentrations directly.

This approach of normalizing the sum of the component mass ratios to unity (or one hundred percent) is valid simply becuase all of the major and minor particles are seen microscopically. That is, the microscopist would deliberately have to ignore a major component to create a serious error. This approach offers substantial reliability over elemental techniques which cannot survey all elements collected on the hi-vol filter, and therefore must presume certain combining elements such as oxygen to calculate a mass balance.

The microscopical approach also makes use of the low temperature ashing procedure to fix the concentrations of organic and inorganic components. In this way, possible cumulative shape errors for particles such as inorganic mica flakes have no effect on rubber tire fragments, which are organic.

A stratified sampling procedure was used to determine particle size distributions and number concentrations. This statistical method provides a means for obtaining similar precisions for the concentrations of the abundant, submicrometer size particles and the sparse, large particles greater than 50 μm in diameter. For example, a single microscopical field of view with a 10X objective may contain only one or two particles greater than 50 μm diameter while there may be several thousand particles below 1 μm diameter. Since the 50 μm particle has a mass equivalent to 125,000 one-micrometer particles it is essential to count the large particles precisely. This is accomplished by using low magnifications (100X) to count and size the large particles in several fields of view. The small particles are counted and sized at high magnifications (625) in just a few fields of view. By knowing the area of the field of view at each magnification, the count data can be merged to produce a complete size distribution. Table E-7 shows raw count data determined by stratified sampling for silicates on a hi-vol filter.

Table E-7. Raw Count Data for a Size Distribution by Stratified Sampling

Size Range, µm	40 x Objective		25 x Objective		10 x Objective		Total Particle in Equal Field of View Area
	Number of Particles	Fields of View	Number of Particles	Fields of View	Number of Particles	Fields of View	
<1	129	3					2122
1-2	95	3					1562
2-3	37	3					608
3-4.5			71	4			257
4.5-6.4			52	4			188
6.4-9.6			41	4			148
9.6-12.8			17	4			61
12.8-16			15	4			54
16-24					29	3	29
24-32					14	3	14
32-40					2	3	2
>40					0	3	0

10 x Objective Field of View Area = 1.49×10^6 μm^2

25 x Objective Field of View Area = 3.09×10^5 μm^2

40 x Objective Field of View Area = 9.06×10^4 μm^2

To calculate the equivalent number of particles in each size range, the number of particles is multiplied by the ratio of areas for each objective magnification. For example, the 3 to 4.5 μm size range in Table E-7 was measured with a 25X objective. The field of view area was 3.09×10^5 μm^2 and a total of 71 particles were counted in 4 fields of view.

The calculations are continued until all of the particle counts in each size range are adjusted to the same sample area. The mass per unit area for a component can now be calculated from this size distribution data.

Calculating Component Concentrations

The mass per unit area for a single component was calculated from the size distribution data. The arithmetic mean diameter for each size interval was converted to the volume of an equivalent sphere and multiplied by the number of particles in that interval:

$$\text{size interval volume} = n_i \frac{4}{3} \pi \left(\frac{\bar{d_i}}{2} \right)^3$$

where n_i is the number of particles in the size interval, i and d_i is the arithmetic mean diameter of the interval. The total volume of the component is simply the sum of all the interval volumes as shown in Table E-8.

This volume per unit filter area was then converted to mass per unit filter area by multiplying the total volume by the component density as shown at the bottom of Table E-8. The densities used for

Table E-8. Mass Per Unit Filter Area Calculations

Size Range, μm	Mean Diameter μm	Mean Equivalent Spherical Volume, μm^3	Number of Particles Per $1.49 \times 10^6\ \mu m^2$	Number of Particles Per cm^2	Volume, μm^3 Per cm^2 of Filter
< 1	0.5	0.07	2122	142,416	9.97×10^3
1-2	1.5	1.77	1562	104,832	186×10^3
2-3	2.5	8.18	608	40,805	334×10^3
3-4.5	3.8	28.7	257	17,248	495×10^3
4.5-6.4	5.5	87.1	188	12,617	1.10×10^6
6.4-9.6	8.0	268	148	9,933	2.66×10^6
9.6-12.8	11.2	723	61	4,094	3.01×10^6
12.8-16	14.4	1563	54	3,604	5.66×10^6
16-24	20.0	4189	29	1,946	8.15×10^6
24-32	28.0	11494	14	940	10.8×10^6
32-40	36.0	24429	2	134	3.27×10^6
> 40	-	-	0	0	
				Sum	35.7×10^6

(Component volume per unit area) x (Component density) = mass per unit area

$$\frac{35.7 \times 10^6\ \mu m^3}{cm^2} \times 2.7 \times 10^{-6}\ \mu g/\mu m^3 = 96.4\ \mu g/cm^2$$

calculating mass concentrations for each component are shown in Table E-9.

Size distributions were used to calculate mass concentrations for the following components in each sample:

silicates
calcite
hematite
rubber tire fragments
flyash
coal
cornstarch.

The remaining components, such as ammonium sulfate and auto exhuast, were determined by non-microscopical procedures or were visually estimated as trace components, such as pollens and magnetic fragments.

In some of the first samples analyzed, silicates and calcite were sized together. To determine mass concentrations for silicates and calcite separately, calcite was re-sized and its mass concentration was subtracted from the combined mass concentrations of silicates and calcite.

Some filter samples were so heavily loaded that it was impossible to perform particle size and concentration measurements. Therefore, the concentrations of certain components for these four samples were estimated (Fire Department #10: 7/15/77, 10/25/77, 12/12/77 and duplicate sample C).

In some samples the opaque, carbonaceous particles obscured the view of minerals. Therefore, a number of components, silicates, calcite, hematite and flyash, were sized on the low temperature ash residue.

Table E-9. Approximate Densities of Particle Components

Components	Density, $\mu g/cm^{-3}$
MINERALS	2.7
quartz and feldspars	2.7
calcite	2.7
others	2.7
clays	1.9
humus	1.4
cement	2.0
hematite	5.2
MOBILE SOURCES	
glassy flyash	1.1
coal fragments	1.5
oil soot	1.1
partially combusted coal	1.1
incinerator flyash	1.9
partially combusted fragments	1.0
NON-SPECIFIC (COMBUSTION) SOURCES	
fine carbonaceous	1.7
ammonium sulfate	1.8
BIOLOGICALS	
pollens, spores, conidia	1.1
plant parts	1.2
starch	1.5
insect parts	1.5
MISCELLANEOUS	
stack iron oxides	5.2
magnetic fragments	7.0
metal fragments	6.5
salt	2.2
sludge	1.5

All of the sized components were measured by Feret's diameter. With this statistical diameter particles can be calculated as equivalent spherical volumes even with aspect ratios of 6:1. The highest aspect ratio components were rubber tire particles (aspect ratio 4:1) and mica flakes (aspect ratio 10:1). Because the mica flakes were a trace component, their high aspect ratio is insignificant.

Inorganic Components

The total inorganic content was set equal to the low temperature ash residue. The ash residue components include:

*silicates
*calcite
mica
clays
*coal flyash
*hematite
magnetic fragments
slag
**ammonium sulfate

Components marked with an asterisk, *, were generally major or minor components that were counted and sized microscopically. The other inorganic components were usually present at trace levels estimated to be significantly below 0.5%. In fact, the collective weight percentage of all the trace concentration, inorganic components were estimated to be less than 0.5%. Therefore, the sum of the major and minor inorganic components were set equal to the LTA residue. Then the component mass ratios from the size and count data were used to calculate percentages for the inorganic components. An example calculation is shown in Table E-10. Ammonium sulfate, marked with a double asterisk, was determined by a direct chemical procedure as described earlier.

Table E-10. Calculation of Inorganic Components Concentrations

Components	$\mu g/m^{-2}$	Mass Ratios Normalized to 100%	Visually Estimated Weight Percent	Component Weight Percent
Silicates	295	73.2	-	41
Calcite	93.5	23.2	-	13
Glassy Flyash	-	-	-	< 0.5
Hematite	14.5	3.6	< 0.5	2.0
Clays, Humus	-	-	3	3
Magnetic Fragments	-	-	< 0.5	< 0.5
Slag	-	-	-	-
Mica	-	-	< 0.5	< 0.5
Totals	4031 0 $\mu g/m^{-2}$	100.0%	3%	59%

LTA Residue = 59%

(% LTA Residue) less (% visually estimated components) = (% major and minor inorganic components)
(59%) - (3%) = (56%)

Organic Components

The calculation of organic component concentrations follows a similar approach to that used for the inorganic components. The organic components include:

humus
**carbonaceous tailpipe exhaust
*rubber tire fragments
*coal fragments
**oil soot
fine carbonaceous particles
*cornstarch
pollens, spores and conidia
plant parts
insect parts.

The components marked with an asterisk were sized, counted and normalized to the adjusted LTA LOSS. The LTA LOSS includes ammonium sulfate and ammonium nitrate which sublime during ashing. Therefore, the concentration for ammonium sulfate was subtracted from the LTA LOSS to obtain an adjusted LTA LOSS which is equal to the organic content.

Those organic components not marked with an asterisk were trace components whose combined concentrations were usually less than 0.5%. Components marked with a double asterisk were determined by measuring elemental tracers and calculating the total concentrations from source coefficient factors. Lead was used for carbonaceous auto exhaust and vanadium was used for oil soot. The reasons for this elemental approach for auto exhuast and oil soot were explained in the Elemental Analysis section.

Table E-11 shows a sample calculation for organic components. This method of calculating the organic and inorganic component concentrations

Table E-11. Calculations of Organic Components Concentrations

Components	$\mu g/cm^{-2}$	Mass Ratios Normalize to 100%	Visually EST. Wt. Pct.	Components Wt. Pct.
Carbonaceous tailpipe exhaust			1*	1
Rubber tire fragments	48.4	92.3		12
Coal fragments	4.0	7.7		1
Oil soot			2*	2
Fine carbonaceous particles			2	2
Cornstarch				0.5
Pollens, spares, conidia			0.5	0.5
Plant parts			2	2
Insect parts			0.5	0.5
Totals	52.4	100	47	20%

LTA Loss = 41%

$(NH_4)_2SO_4$ content = 21%

Organic content = 20%

* Determined through elemental analyses.

was used for all samples except three samples from Fire Department #10 which were too heavily loaded to perform particle counting. The results for these samples were estimated visually.

Microscopical Data Sheets

The analytical results for the eighteen hi-vol samples are reported on data forms with samples grouped by day.

REPORT ON PARTICLE IDENTIFICATION

Project C6409 - Baltimore TSP Study

Date: 6/9/77

SITE:	FD #10	Fort McHenry	
TSP ($\mu g/m^3$):	63	59	
% ASHABLE:	41%	51%	

COMPONENTS	NORMALIZED CONCENTRATION Weight %	NORMALIZED CONCENTRATION Weight %	NORMALIZED CONCENTRATION Weight %
MINERALS			
silicates	41	44	
calcite	13	4	
mica	<0.5	<0.5	
clays, humus	3	1	
MOBILE SOURCES			
carbonaceous tailpipe exhaust	1	1	
rubber tire fragments	12	2	
COMBUSTION SOURCES			
glassy flyash	<0.5	<0.5	
coal fragments	1	1	
oil soot	2	3	
NON-SPECIFIC COMBUSTION SOURCES			
fine carbonaceous particles	2	1	
recrystallized sulfates	21	30	
INDUSTRIAL EMISSIONS			
cornstarch	<0.5	11	
hematite	2	<0.5	
magnetic fragments	<0.5	0.5	
slag			
BIOLOGICALS			
pollens, spores, conidia	<0.5	<0.5	
plant parts	2	<0.5	
insect parts	<0.5	<0.5	

REPORT ON PARTICLE IDENTIFICATION

Project C6409 - Baltimore TSP Study

Date: 6/21/77

SITE:	FD #22		
TSP ($\mu g/m^3$):	60		
% ASHABLE:	44%		

COMPONENTS	NORMALIZED CONCENTRATION Weight %	NORMALIZED CONCENTRATION Weight %	NORMALIZED CONCENTRATION Weight %
MINERALS			
silicates	52		
calcite	2		
mica	<0.5		
clays, humus	<0.5		
MOBILE SOURCES			
carbonaceous tailpipe exhaust	1		
rubber tire fragments	14		
COMBUSTION SOURCES			
glassy flyash	<0.5		
coal fragments	2		
oil soot	1		
NON-SPECIFIC COMBUSTION SOURCES			
fine carbonaceous particles	<0.5		
recrystallized sulfates	24		
INDUSTRIAL EMISSIONS			
cornstarch	<0.5		
hematite	1		
magnetic fragments	<0.5		
slag			
BIOLOGICALS			
pollens, spores, conidia	2		
plant parts	2		
insect parts	<0.5		

REPORT ON PARTICLE IDENTIFICATION

Project C6409 - Baltimore TSP Study

Date: 7/15/77

SITE:	FD #10	FD #22	
TSP ($\mu g/m^3$):	221	149	
% ASHABLE:	29%	40%	

COMPONENTS	NORMALIZED CONCENTRATION Weight %	NORMALIZED CONCENTRATION Weight %	NORMALIZED CONCENTRATION Weight %
MINERALS			
silicates	40	54	
calcite	30	3	
mica	<0.5	<0.5	
clays, humus	1	1	
MOBILE SOURCES			
carbonaceous tailpipe exhaust	1	1	
rubber tire fragments	7	9	
COMBUSTION SOURCES			
glassy flyash	<0.5	1	
coal fragments	2	5	
oil soot	2	1	
NON-SPECIFIC COMBUSTION SOURCES			
fine carbonaceous particles	3	4	
recrystallized sulfates	13	16	
INDUSTRIAL EMISSIONS			
cornstarch	<0.5	3	
hematite	0.5	1	
magnetic fragments	<0.5	0.5	
slag			
BIOLOGICALS			
pollens, spores, conidia	1	1	
plant parts	<0.5	<0.5	
insect parts	<0.5	<0.5	

REPORT ON PARTICLE IDENTIFICATION

Project C6409 - Baltimore TSP Study

Date: 8/2/77

SITE:	Fort McHenry		
TSP ($\mu g/m^3$):	154		
% ASHABLE:	65%		

COMPONENTS	NORMALIZED CONCENTRATION Weight %	NORMALIZED CONCENTRATION Weight %	NORMALIZED CONCENTRATION Weight %
MINERALS			
silicates	23		
calcite	5		
mica	<0.5		
clays, humus	2		
MOBILE SOURCES			
carbonaceous tailpipe exhaust	0.5		
rubber tire fragments	5		
COMBUSTION SOURCES			
glassy flyash	1		
coal fragments	0.5		
oil soot	1		
NON-SPECIFIC COMBUSTION SOURCES			
fine carbonaceous particles	1		
recrystallized sulfates	15		
INDUSTRIAL EMISSIONS			
cornstarch	41		
hematite	2		
magnetic fragments	<0.5		
slag			
BIOLOGICALS			
pollens, spores, conidia	<0.5		
plant parts	<0.5		
insect parts	1		

REPORT ON PARTICLE IDENTIFICATION

Project C6409 - Baltimore TSP Study

Date: 9/19/77

SITE:	FD #22		
TSP ($\mu g/m^3$):	108		
% ASHABLE:	42%		

COMPONENTS	NORMALIZED CONCENTRATION Weight %	NORMALIZED CONCENTRATION Weight %	NORMALIZED CONCENTRATION Weight %
MINERALS			
silicates	45		
calcite	7		
mica	<0.5		
clays, humus	4		
MOBILE SOURCES			
carbonaceous tailpipe exhaust	1		
rubber tire fragments	11		
COMBUSTION SOURCES			
glassy flyash	1		
coal fragments	3		
oil soot	2		
NON-SPECIFIC COMBUSTION SOURCES			
fine carbonaceous particles	2		
recrystallized sulfates	22		
INDUSTRIAL EMISSIONS			
cornstarch	1		
hematite	1		
magnetic fragments	1		
slag			
BIOLOGICALS			
pollens, spores, conidia	1		
plant parts	<0.5		
insect parts	<0.5		

REPORT ON PARTICLE IDENTIFICATION

Project C6409 - Baltimore TSP Study

Date: 9/25/77

SITE:	FD #10	FD #22	Fort McHenry
TSP ($\mu g/m^3$):	51	38	39
% ASHABLE:	39%	50%	51%
COMPONENTS	NORMALIZED CONCENTRATION Weight %	NORMALIZED CONCENTRATION Weight %	NORMALIZED CONCENTRATION Weight %
MINERALS			
silicates	35	37	24
calcite	10	1	4
mica	<0.5	<0.5	<0.5
clays, humus	1	1	1
MOBILE SOURCES			
carbonaceous tailpipe exhaust	1	1	1
rubber tire fragments	11	12	6
COMBUSTION SOURCES			
glassy flyash	<0.5	1	<0.5
coal fragments	2	2	1
oil soot	3	2	9
NON-SPECIFIC COMBUSTION SOURCES			
fine carbonaceous particles	<0.5	<0.5	<0.5
recrystallized sulfates	36	40	50
INDUSTRIAL EMISSIONS			
cornstarch	<0.5	1	<0.5
hematite	<0.5	1	2
magnetic fragments	<0.5	<0.5	<0.5
slag			
BIOLOGICALS			
pollens, spores, conidia	<0.5	1	1
plant parts	<0.5	<0.5	<0.5
insect parts	<0.5	1	<0.5

REPORT ON PARTICLE IDENTIFICATION

Project C6409 - Baltimore TSP Study

Date: 10/25/77

SITE:	FD #10	Fort McHenry	
TSP ($\mu g/m^3$):	306	118	
% ASHABLE:	23%	48%	

COMPONENTS	NORMALIZED CONCENTRATION Weight %	NORMALIZED CONCENTRATION Weight %	NORMALIZED CONCENTRATION Weight %
MINERALS			
silicates	17	44	
calcite	25	2	
mica	<0.5	<0.5	
clays, humus	2	4	
MOBILE SOURCES			
carbonaceous tailpipe exhaust	1	1	
rubber tire fragments	3	7	
COMBUSTION SOURCES			
glassy flyash	<0.5	<0.5	
coal fragments	3	8	
oil soot	1	1	
NON-SPECIFIC COMBUSTION SOURCES			
fine carbonaceous particles	3	5	
recrystallized sulfates	13	18	
INDUSTRIAL EMISSIONS			
cornstarch	<0.5	8	
hematite	<0.5	1	
magnetic fragments	<0.5	<0.5	
slag	31	<0.5	
BIOLOGICALS			
pollens, spores, conidia	<0.5	<0.5	
plant parts	<0.5	<0.5	
insect parts	<0.5	<0.5	

REPORT ON PARTICLE IDENTIFICATION

Project C6409 - Baltimore TSP Study

Date: 11/24/77

SITE:	FD #10	FD #22	Fort McHenry
TSP ($\mu g/m^3$):	42	52	41
% ASHABLE:	45%	47%	60%
COMPONENTS	NORMALIZED CONCENTRATION Weight %	NORMALIZED CONCENTRATION Weight %	NORMALIZED CONCENTRATION Weight %
MINERALS			
silicates	32	35	32
calcite	4	4	2
mica	<0.5	<0.5	<0.5
clays, humus	4	1	1
MOBILE SOURCES			
carbonaceous tailpipe exhaust	2	2	2
rubber tire fragments	11	24	14
COMBUSTION SOURCES			
glassy flyash	1	<0.5	<0.5
coal fragments	5	1	2
oil soot	2	2	2
NON-SPECIFIC COMBUSTION SOURCES			
fine carbonaceous particles	2	1	2
recrystallized sulfates	35	32	45
INDUSTRIAL EMISSIONS			
cornstarch	0.5	<0.5	1
hematite	2	<0.5	<0.5
magnetic fragments	<0.5	<0.5	<0.5
slag			
BIOLOGICALS			
pollens, spores, conidia	<0.5	<0.5	<0.5
plant parts	<0.5	<0.5	<0.5
insect parts	<0.5	<0.5	<0.5

REPORT ON PARTICLE IDENTIFICATION

Project C6409 - Baltimore TSP Study

Date: 12/12/77

SITE:	FD #10	FD #22	Fort McHenry
TSP ($\mu g/m^3$):	169	129	85
% ASHABLE:	31%	40%	51%
COMPONENTS	NORMALIZED CONCENTRATION Weight %	NORMALIZED CONCENTRATION Weight %	NORMALIZED CONCENTRATION Weight %
MINERALS			
silicates	30	37	33
calcite	40	14	14
mica	<0.5	<0.5	<0.5
clays, humus	<0.5	5	1
MOBILE SOURCES			
carbonaceous tailpipe exhaust	1	1	1
rubber tire fragments	8	10	12
COMBUSTION SOURCES			
glassy flyash	<0.5	1	1
coal fragments	1	1	2
oil soot	1	2	4
NON-SPECIFIC COMBUSTION SOURCES			
fine carbonaceous particles	6	5	3
recrystallized sulfates	13	17	25
INDUSTRIAL EMISSIONS			
cornstarch	<0.5	1	5
hematite	0.5	2	<0.5
magnetic fragments	<0.5	<0.5	<0.5
slag			
BIOLOGICALS			
pollens, spores, conidia	<0.5	<0.5	<0.5
plant parts	<0.5	<0.5	<0.5
insect parts	<0.5	<0.5	<0.5

APPENDIX F

ORIENTATION OF POINT SOURCES TO HI-VOL SAMPLERS

The first three tables in this appendix identify the point sources which are upwind of each of three Baltimore hi-vol sites (namely, Fire Dept #22, Fire Dept #10, and Fort McHenry) for each of 16 sectors. The percentage of the time and the average wind speed with which the wind was from each sector is also listed for each of the 9 days for which particulate samples are analyzed in this report. A fourth table identifies the names of the point sources.

TABLE F-1

Site: Fire Department #22 Monitor

Percent Occurrence WD / Average WS for WD **

Wind Direction	Major Sources Upwind* (See Table F-4)	6/9/77	6/21	7/15	8/2	9/19	9/25	10/25	11/24	12/12
Date:		6/9/77	6/21	7/15	8/2	9/19	9/25	10/25	11/24	12/12
Daily Average Wind Speed (mph):		6.2	6.3	2.0	2.8	3.5	6.5	3.2	4.3	4.[illegible]
		% Calm 0	% Calm 0	% Calm 13	% Calm 4	% Calm 0	% Calm 0	% Calm 8	% Calm 13	% Calm 17
N	77, 101			4 / 0.1					17 / 10.8	4 / 5.[illegible]
NNE	80, 72, 92			4 / 1.0			4 / 7.0			
NE	83, 72, 107, 94, 20, 44, 45, 39, 41, 42, 40						42 / 5.7			
ENE	86, 103, 107, 18, 31, 10, 17, 44, 41, 43			4 / 1.0			50 / 6.5			
E	93, 69			4 / 3.0			4 / 4.0			
ESE	56, 30, 115, 130			17 / 2.3		8 / 4.5				
SE	57, 70, 109, 74, 16, 114, 128, 118, 126 132, 113, 119, 129, 127, 116, 112, 123, 121, 124, 24, 111, 120, 122, 125, 131, 117			17 / 3.5		4 / 1.0				
SSE	78, 76, 2, 1, 9			8 / 1.5		13 / 3.7				8 / [illegible]
S	65, 88, 58, 66, 60, 59, 98, 82, 100, 96, 8, 68, 13, 62, 6, 3			13 / 2.0		8 / 2.5				38 / [illegible]
SSW	79, 63, 12, 4			4 / 6.0					4 / 4.0	13 / [illegible]
SW	108, 61, 52, 99, 71, 110, 21, 12, 11, 5, 7					21 / 3.6			8 / 5.0	4 / 2.[illegible]
WSW	108, 73, 87, 84, 61, 99, 51, 21, 29, 32, 22, 14, 46, 47		38 / 3.6	13 / 0.4		13 / 2.7			4 / 3.0	13 / 1.[illegible]
W	106, 85, 49, 89, 54, 91, 90, 75, 105, 102, 32, 14, 48		8 / 2.5			13 / 2.3			33 / 5.4	4 / 6.[illegible]
WNW	95, 53, 97, 67, 104, 15, 23, 33, 34		42 / 7.7			17 / 6.5			4 / 8.0	
NW	50, 53, 64, 27, 15, 26, 25, 35, 36, 37, 38		13 / 8.3			4 / 4.0			4 / 7.0	
NNW	101, 19, 28								13 / 11.7	

* The monitor to source distance generally increases from left to right.

** WD is direction from which the wind is blowing. WS is the wind speed in miles per hour (mph).

Note: Sun and Chesapeake WS and WD are used with the data gaps filled in by Baltimore-Washington International Airport (BWI) data. Often BWI WS are higher than Sun and Chesapeake WS by about a factor of 2. There is generally good agreement between BWI and Sun and Chesapeake WD. Sun and Chesapeake WS and WD are hourly averages. BWI WS and WD are instantaneous values.

TABLE F-2

Site: Fire Department #10 Monitor

Wind Direction	Date:	6/9/77	6/21	7/15	8/2	9/19	9/25	10/25	11/24	12/12
		Percent Occurrence WD / Average WS for WD **								
	Daily Average Wind Speed (mph):	6.2	6.3	2.0	2.8	3.5	6.5	3.2	4.3	4.6
	Major Sources Upwind* (See Table F-4)	% Calm 0	% Calm 0	% Calm 13	% Calm 4	% Calm 0	% Calm 0	% Calm 8	% Calm 13	% Calm 17
N	65, 78, 56, 86, 83, 77, 80, 72, 92, 101			4 / 0.1				4 / 5.0	17 / 10.8	4 / 5.
NNE	76, 109, 70, 57, 93, 103, 69, 107, 94			4 / 1.0			4 / 7.0			
NE	74, 18, 31, 10, 20, 44, 39, 41, 45 42, 43, 40						42 / 5.7			
ENE	30, 17, 41, 43, 40	8 / 1.5		4 / 1.0			50 / 6.5			
E	16, 30, 115, 130			4 / 3.0			4 / 4.0	29 / 2.9		
ESE	16, 24, 111, 112, 123, 113, 119, 129, 114, 116, 117, 118, 126, 132, 120, 122, 125, 121, 124, 127, 128, 131			17 / 2.3				21 / 3.6		
SE	Zip			17 / 3.5						
SSE	98, 82, 62, 68, 2, 1, 9	13 / 4.7		8 / 1.5				13 / 6.0		8 / 4.
S	82, 62, 68, 6, 3, 98	17 / 6.8		13 / 2.0						38 / 4.
SSW	88, 58, 59, 100, 96, 8, 13, 4	21 / 6.8		4 / 6.0					4 / 4.0	13 / 6.
SW	88, 58, 60, 66, 4, 12, 11, 5, 7								8 / 5.0	4 / 2.
WSW	63, 22, 5, 47	8 / 6.0		13 / 0.4					4 / 3.0	13 / 1.
W	79, 71, 110, 21, 29, 32, 14, 46, 48	4 / 4.0						25 / 5.0	33 / 5.4	4 / 6.
WNW	79, 52, 99, 51, 84, 89, 54, 75, 102, 105, 14, 23, 33	21 / 5.6							4 / 8.0	
NW	37, 38, 61, 73, 52, 84, 87, 89, 49, 91, 97, 90, 104, 67, 15, 25, 26, 35, 34, 36	8 / 8.5							4 / 7.0	
NNW	73, 108, 106, 85, 95, 50, 53, 64, 27, 19, 28								13 / 11.7	

* The monitor to source distance generally increases from left to right.

** WD is direction from which the wind is blowing. WS is the wind speed in miles per hour (mph).

Note: Sun and Chesapeake WS and WD are used with the data gaps filled in by Baltimore-Washington International Airport (BWI) data. Often BWI WS are higher than Sun and Chesapeake WS by about a factor of 2. There is generally good agreement between BWI and Sun and Chesapeake WD. Sun and Chesapeake WS and WD are hourly averages. BWI WS and WD are instantaneous values.

TABLE F-3

Site: Fort McHenry Monitor

Wind Direction	Major Sources Upwind* (See Table F-4)	Percent Occurrence WD / Average WS for WD **								
	Date:	6/9/77	6/21	7/15	8/2	9/19	9/25	10/25	11/24	12/12
	Daily Average Wind Speed (mph):	6.2	6.3	2.0	2.8	3.5	6.5	3.2	4.3	4.6
		% Calm 0	% Calm 0	% Calm 13	% Calm 4	% Calm 0	% Calm 0	% Calm 8	% Calm 13	% Calm 17
N	108, 77, 101							4 / 5.0	17 / 10.8	4 / 5.0
NNE	86, 83, 77, 80, 72, 92						4 / 7.0			
NE	56, 86, 103, 93, 107, 94, 20, 44, 39, 41, 42, 40, 45						42 / 5.7			
ENE	69, 18, 31, 10, 17, 44, 41, 43	8 / 1.5					50 / 6.5			
E	109, 57, 70, 74						4 / 4.0	29 / 2.9		
ESE	78, 76, 74, 30, 16, 115, 130, 128, 118, 126, 132, 113, 119, 129, 112, 123, 111, 114				4 / 5.0			21 / 3.6		
SE										
SSE	65, 98, 82, 68, 2, 1, 9	13 / 4.7			17 / 1.3			13 / 6.0		8 / [illegible]
S	88, 66, 58, 60, 59, 100, 96, 8, 13, 62, 6, 3	17 / 6.8			13 / 1.4					38 / [illegible]
SSW	79, 63, 4, 12	21 / 6.8							4 / 4.0	13 / [illegible]
SW	71, 12, 5, 7, 11				4 / 5.0				8 / 5.0	4 / [illegible]
WSW	52, 99, 110, 21, 29, 22, 47	8 / 6.0			8 / 3.0				4 / 3.0	13 / [illegible]
W	61, 73, 84, 51, 89, 54, 75, 102, 32, 14, 46, 48	4 / 4.0			17 / 1.1			25 / 5.0	33 / 5.4	4 / [illegible]
WNW	73, 87, 49, 89, 91, 90, 67, 104, 105, 23, 33, 34	21 / 5.6			21 / 2.8				4 / 8.0	
NW	106, 85, 95, 53, 97, 64, 15, 25, 26, 35 36, 37, 38	8 / 8.5			13 / 3.7				4 / 7.0	
NNW	108, 50, 27, 19, 28								13 / 11.7	

* The monitor to source distance generally increases from left to right.

** WD is direction from which the wind is blowing. WS is the wind speed in miles per hour (mph).

Note: Sun and Chesapeake WS and WD are used with the data gaps filled in by Baltimore-Washington International Airport (BWI) data. Often BWI WS are higher than Sun and Chesapeake WS by about a factor of 2. There is generally good agreement between BWI and Sun and Chesapeake WD. Sun and Chesapeake WS and WD are hourly averages. BWI WS and WD are instantaneous values.

TABLE F-4

SOURCE	SOURCE NUMBER
BG&E (Wagner)	1
Kennecott	2
Crownsville	3
Exxon Chemical	4
Md. House of Correction	5
Diamond Shamrock	6
D. C. Children's Center	7
Amerada Hess	8
U.S. Naval Academy	9
U.S. Coast Guard	10
National Security Agency	11
Fort Meade	12
U.S. Agri-Chem	13
Spring Grove	14
Mt. Wilson St. Hospital	15
BG&E (Riverside)	16
BG&E (Crane)	17
Eastern Stainless Steel	18
Harry T. Campbell - Texas	19
Harry T. Campbell - White Marsh	20
Carling Brewing Co.	21
Joseph Seagram	22
Harry T. Campbell - Marriot	23
Arundel Corp. - Canal Road	24
Rosewood St. Hospital	25
Sweetheart Cup	26
Federal Paperboard	27
Baltimore Bio Lab	28
Majestic Distillers	29
Stemmers Run JHS	30
Back River STP	31
Concorde Yachts	32
Springfield St. Hospital	33
Lehigh Portland Cement	34
Congoleum Industries	35
Southern States - BA	36
Southern States - YO	37
Taneytown Grain	38
Bata Shoe Inc.	39
J.M. Huber	40
BG&E (Perryman)	41
York Bldg. Products	42
Aberdeen Proving Ground	43
Edgewood Arsenal	44
avis Quarry Inc.	45
Simkins Industries	46
General Electric	47
Glenelg Manor Association	48

(Continued)

TABLE F-4 (Continued)

SOURCE	SOURCE NUMBER
BG&E (Terminal)	49
BG&E (Spring Garden)	50
BG&E (Westport)	51
BG&E (Gould)	52
Md. Penitentiary	53
Montgomery Ward & Co.	54
Exxon Company	55
National Brewing Co.	56
GAF Corporation	57
Chevron Asphalt Co.	58
FMC Corp. - Org. Chem.	59
Olin Matheson	60
Allied Chemical	61
Davison Chemical	62
General Refractories	63
Johns Hopkins University	64
Agrico Chemical Company	65
Continental Oil	66
Abex Corporation	67
Glidden-Durkee (Hawkins Point)	68
Glidden-Durkee (Eastern)	69
Lever Brothers	70
Arundel Corporation	71
Tomke Aluminum	72
Proctor & Gamble	73
Federal Yeast Corporation	74
Maryland Glass Corporation	75
Southern Industries	76
Monarch Rubber Co.	77
National Gypsum Co.	78
Md. Shipbuilding & Drydock	79
BG&E (Philadelphia Road)	80
Bethlehem Steel - Key Highway	81
American Oil Company	82
Schluderberg-Kurdle	83
Carr-Lowery Glass	84
Lock (GE) Insulator	85
F&M Schaefer Brewing	86
American Sugar	87
M&T Chemical	88
Eastern Products	89
Koppers (Bush Street)	90
Koppers (Scott Street)	91
Armco Steel	92
GMAD	93
Pulaski Highway Incinerator	94
City Jail	95
American Oil	96
Dept. of General Services	97
Shell Oil	98
Inter Briquetting Corp.	99
Hess Oil	100

(Continued)

TABLE F-4 (Concluded)

SOURCE	SOURCE NUMBER
Morgan University	101
MTA	102
Baltimore City Hospital	103
Luthern Hospital	104
A & P	105
Philadelphia Quartz	106
Fort Holabird	107
J. S. Young Co.	108
American Standard	109
Reedbird Ave. Incinerator	110
Beth Steel - Penwood	111
Beth Steel - B Street	112
Beth Steet - 7th Street	113
Beth Steel - Tin Mill	114
Beth Steel - Hot Strip Mill	115
Beth Steel - #2 Boiler House	116
Beth Steel - #1 Boiler House	117
Beth Steel - Misc. Fuel Burning	118
Beth Steel - BOF	119
Beth Steel - Coke Handling	120
Beth Steel - Coke Handling	121
Beth Steel - Ore Handling	122
Beth Steel - Blast Furnace	123
Beth Steel - Coke Battery	124
Beth Steel - Sintering Plant	125
Beth Steel - Open Hearth	126
Beth Steel - Plate Mill	127
Beth Steel - Soaking Pits	128
Beth Steel - Sheet Mill	129
Beth Steel - Hot Strip Mill	130
Beth Steel - Claus Sulfur Recovery	131
Beth Steel - Misc. Processes	132

APPENDIX G

WIND DIRECTIONS ON HI-VOL SAMPLING DAYS

The 24-hour resultant wind direction, determined as the vector mean of 24 hourly values, and the hourly deviation of the wind from the resultant wind are listed for 9 days on which hi-vol filter samples were analyzed in this report. A wind rose showing the frequency of occurrence of 16 wind direction sectors on each sampling day is also presented following the listings.

TABLE G-1. HOURLY WIND DEVIATIONS

Hour Date: June 7 1977 Ave. WD: 224°	Hourly Deviation from Ave. WD	Hour Date: July 15 1977 Ave. WD: 144°	Hourly Deviation from Ave. WD
00	44	00	C
01	21.5	01	C
02	44	02	-103.5
03	21.5	03	-103.5
04	44	04	-103.5
05	66.5	05	C
06	66.5	06	144
07	66.5	07	121.5
08	44	08	76.5
09	21.5	09	31.5
10	21.5	10	54
11	21.5	11	31.5
12	-68.5	12	31.5
13	156.5	13	31.5
14	156.5	14	9
15	-23.5	15	9
16	-68.5	16	9
17	-68.5	17	9
18	-23.5	18	-13.5
19	-46	19	-13.5
20	-91	20	-36
21	-91	21	-36
22	-68.5	22	-58.5
23	-68.5	23	-36

(continued)

Hour Date: June 21, 19[illegible] Ave. WD: 270°	Hourly Deviation from Ave. WD
00	22.5
01	22.5
02	22.5
03	22.5
04	22.5
05	22.5
06	0
07	-22.5
08	-22.5
09	-22.5
10	-22.5
11	-22.5
12	-22.5
13	-22.5
14	-45
15	-45
16	-22.5
17	-22.5
18	-45
19	-22.5
20	0
21	22.5
22	22.5
23	22.5

Hour Date: Aug 2, 1977 Ave. WD: 247°	Hourly Deviation from Ave. WD
00	-.5
01	-23
02	-68
03	-45.5
04	-23
05	-23
06	-45.5
07	-67
08	-68
09	-45.5
10	-.5
11	-45.5
12	-23
13	-45.5
14	89.5
15	134.5
16	67
17	22
18	79.5
19	89.5
20	67
21	89.5
22	67
23	0

(continued)

TABLE G-1. HOURLY WIND DEVIATIONS (continued)

Hour Date: Sep 19, 1977 Ave.WD: 229°	Hourly Deviation from Ave. WD	Hour Date: Sep 25, 19[illegible] Ave.WD: 57°	Hourly Deviation from Ave. WD
00	4	00	-10.5
01	4	01	-10.5
02	4	02	-33
03	-18.5	03	12
04	4	04	12
05	-18.5	05	34.5
06	-41	06	12
07	49	07	12
08	4	08	12
09	-18.5	09	12
10	-26	10	12
11	-63.5	11	-10.5
12	-41	12	12
13	94	13	-10.5
14	116.5	14	12
15	6.5	15	-10.5
16	71.5	16	-10.5
17	71.5	17	12
18	71.5	18	-10.5
19	49	19	-10.5
20	-63.5	20	-10.5
21	-63.5	21	-10.5
22	-63.5	22	-10.5
23	-41	23	-10.5

(continued)

Hour Date: Oct 25, 977 Ave.WD: 119°	Hourly Deviation from Ave. WD	Hour Date: [illegible] Ave.WD: 291°	Hourly Deviation from Ave. WD
00	29	00	21
01	-151	01	21
02	-151	02	21
03	-151	03	66
04	C	04	66
05	-151	05	21
06	-151	06	-1.5
07	119	07	21
08	-151	08	-24
09	C	09	43.5
10	29	10	C
11	6.5	11	21
12	29	12	21
13	6.5	13	21
14	29	14	C
15	6.5	15	38.5
16	-38.5	16	C
17	-38.5	17	~~[illegible]~~ -6[illegible]
18	-38.5	18	-46.5
19	6.5	19	-46.5
20	29	20	-46.5
21	6.5	21	~~[illegible]~~
22	29	22	~~[illegible]~~
23	29	23	~~[illegible]~~

(continued)

Hour Date: Dec 15, 97 Ave.WD: 199°	Hourly Deviation from Ave. WD
00	-48.5
01	C
02	C
03	-71
04	-48.5
05	-48.5
06	~~199~~ -161
07	C
08	C
09	41.5
10	41.5
11	19
12	19
13	-3.5
14	-3.5
15	19
16	19
17	19
18	19
19	19
20	19
21	19
22	-3.5
23	-26

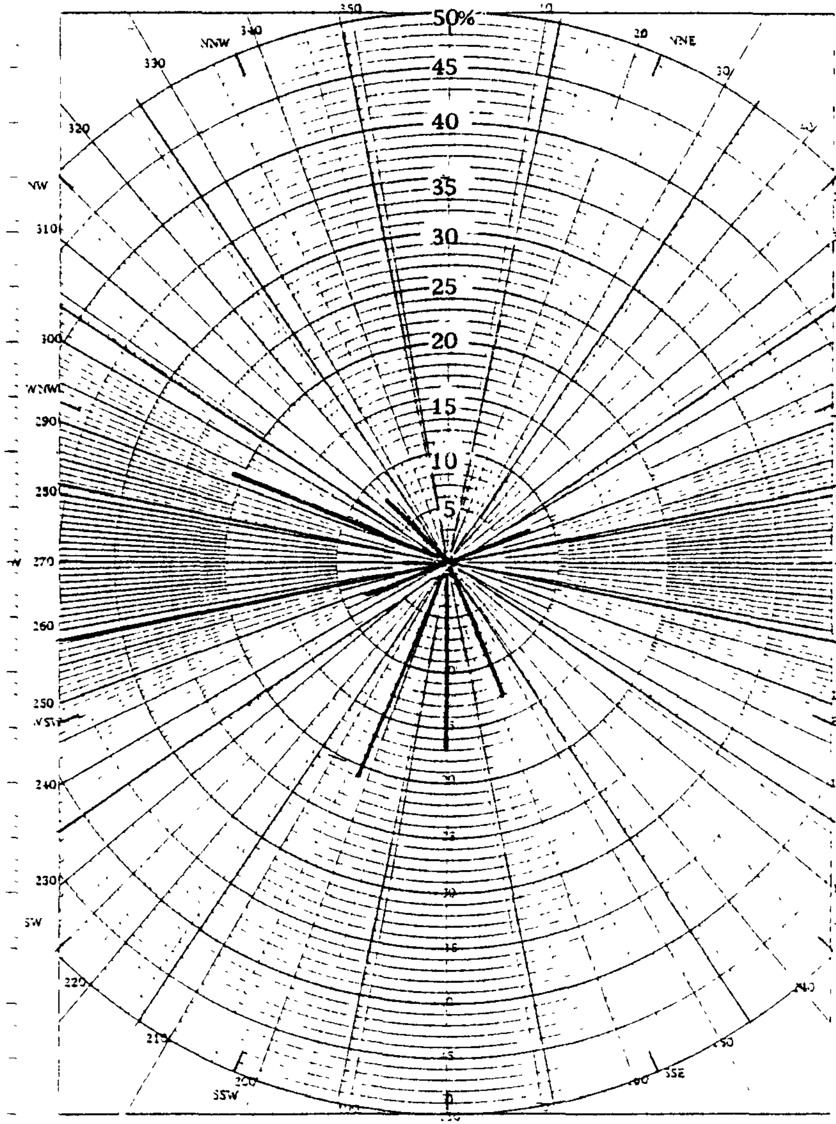

Figure G-1. Sun and Chesapeake (Fairfield), and BWI Airport Data, June 9, 1977 (0% calm)

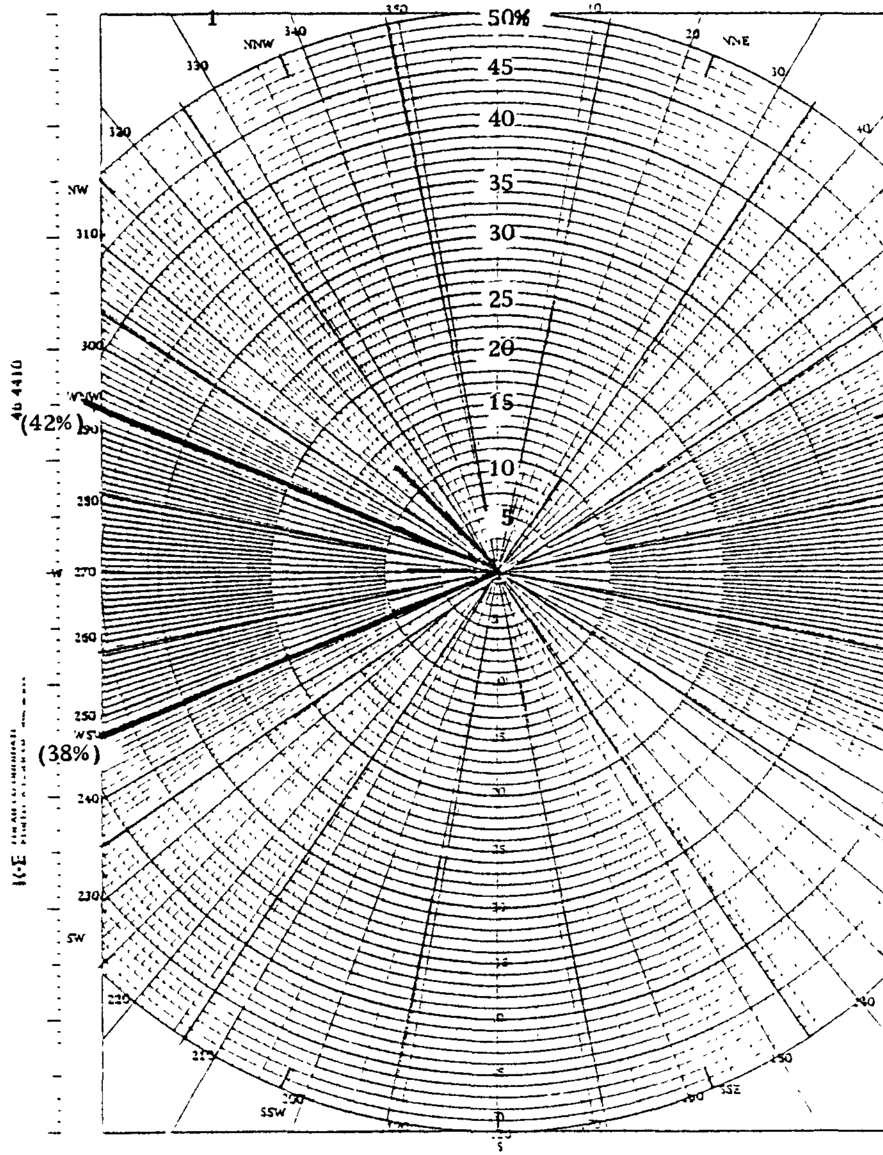

Figure G-2. Sun and Chesapeake (Fairfield) Data, June 21, 1977 (0% calm)

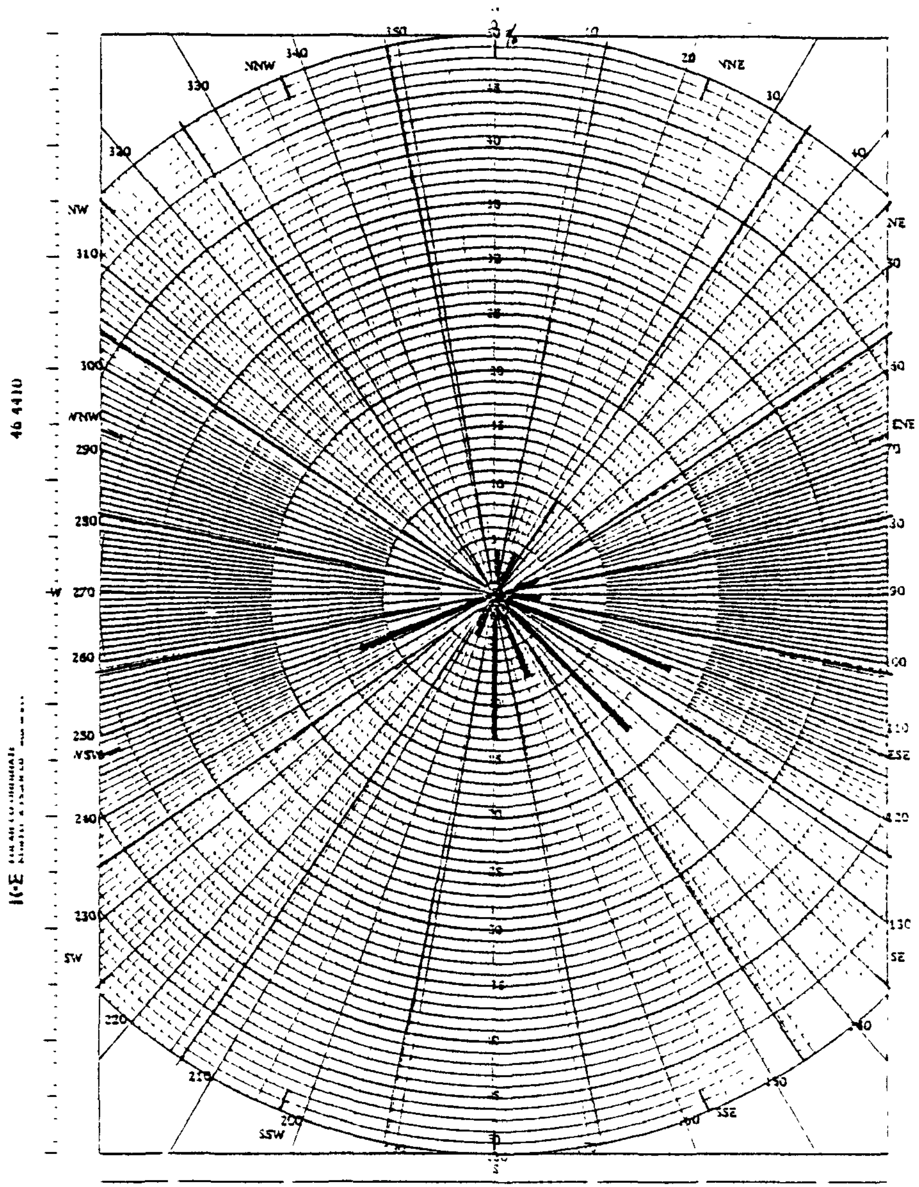

Figure G-3. Sun and Chesapeake, and BWI Airport Data, July 15, 1977 (13% calm)

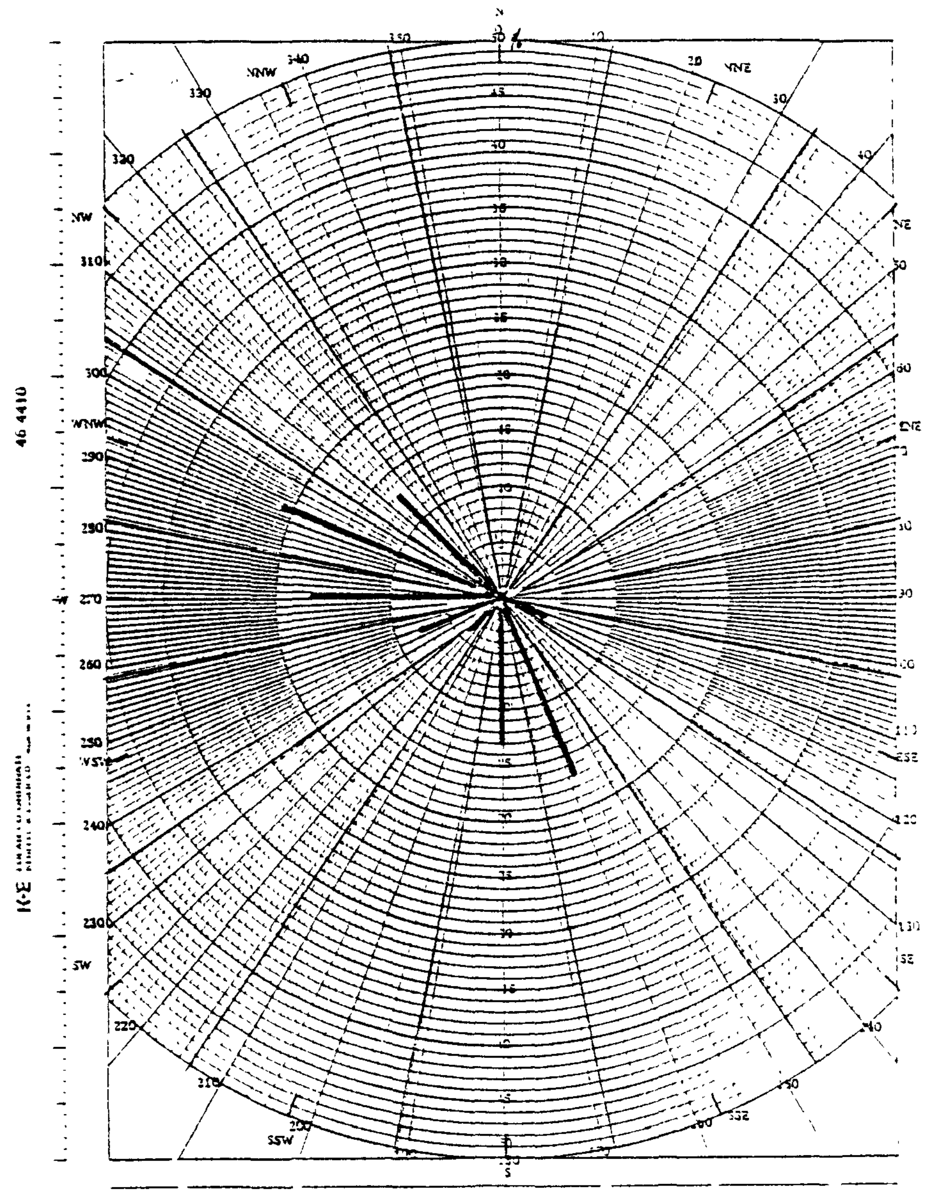

Figure G-4. Sun and Chesapeake (Fairfield) Data August 2, 1977 (4% calm)

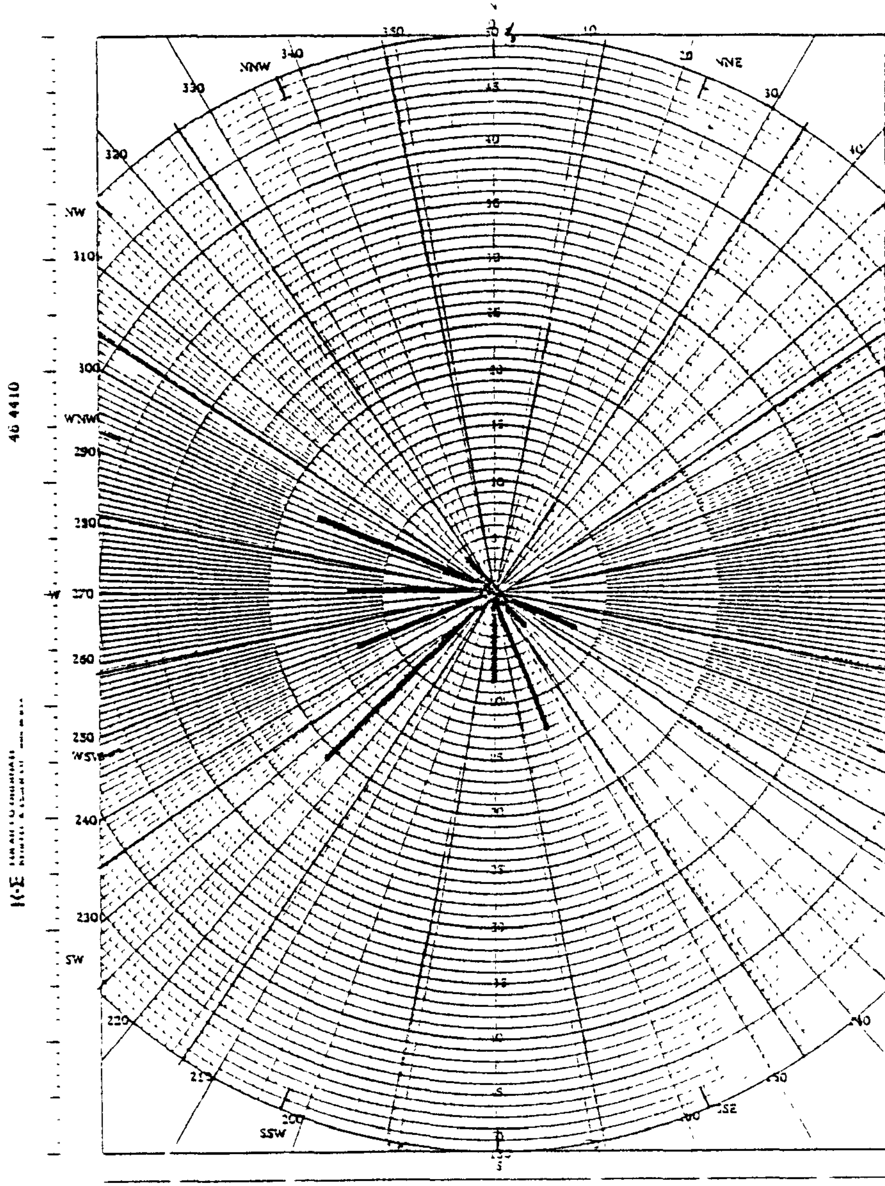

Figure G-5. Sun and Chesapeake, and BWI Airport Data, September 19, 1977 (0% calm)

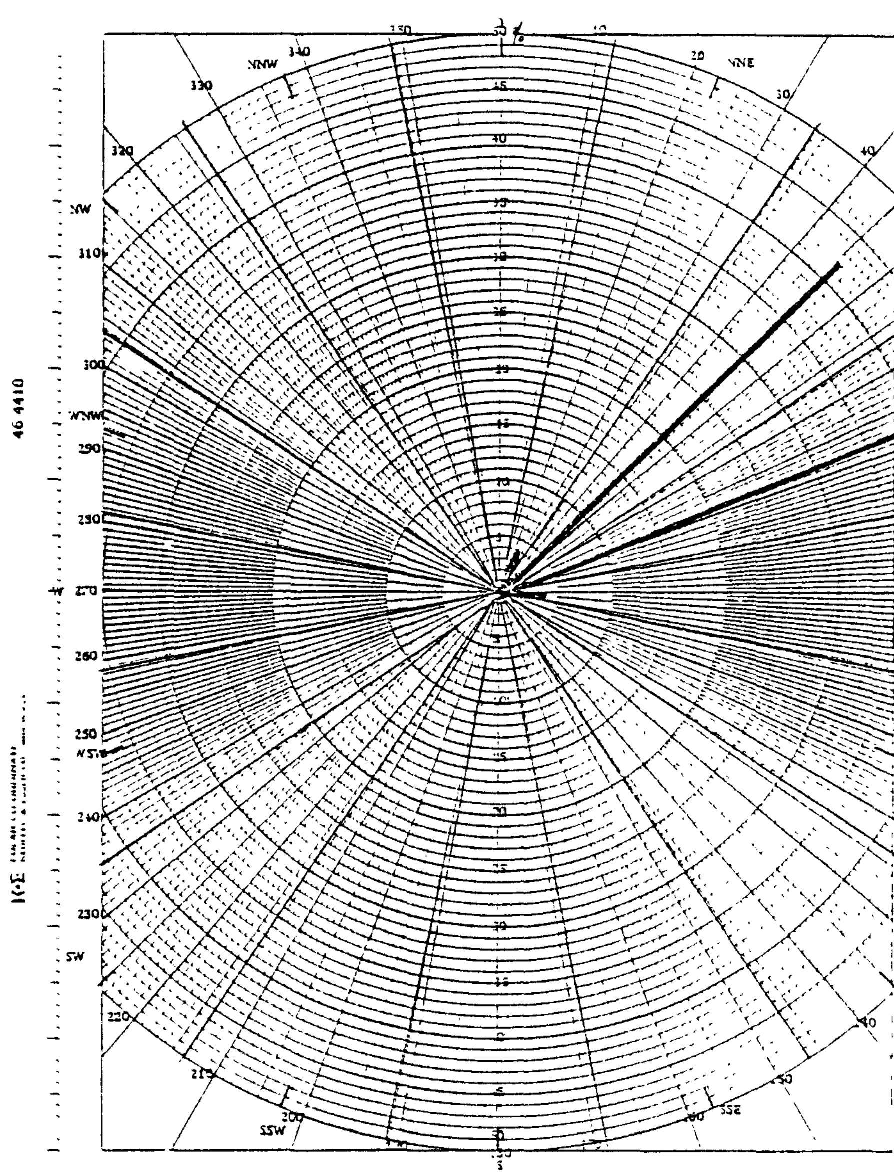

Figure G-6. Sun and Chesapeake (Fairfield) Data, September 25, 1977 (0% calm)

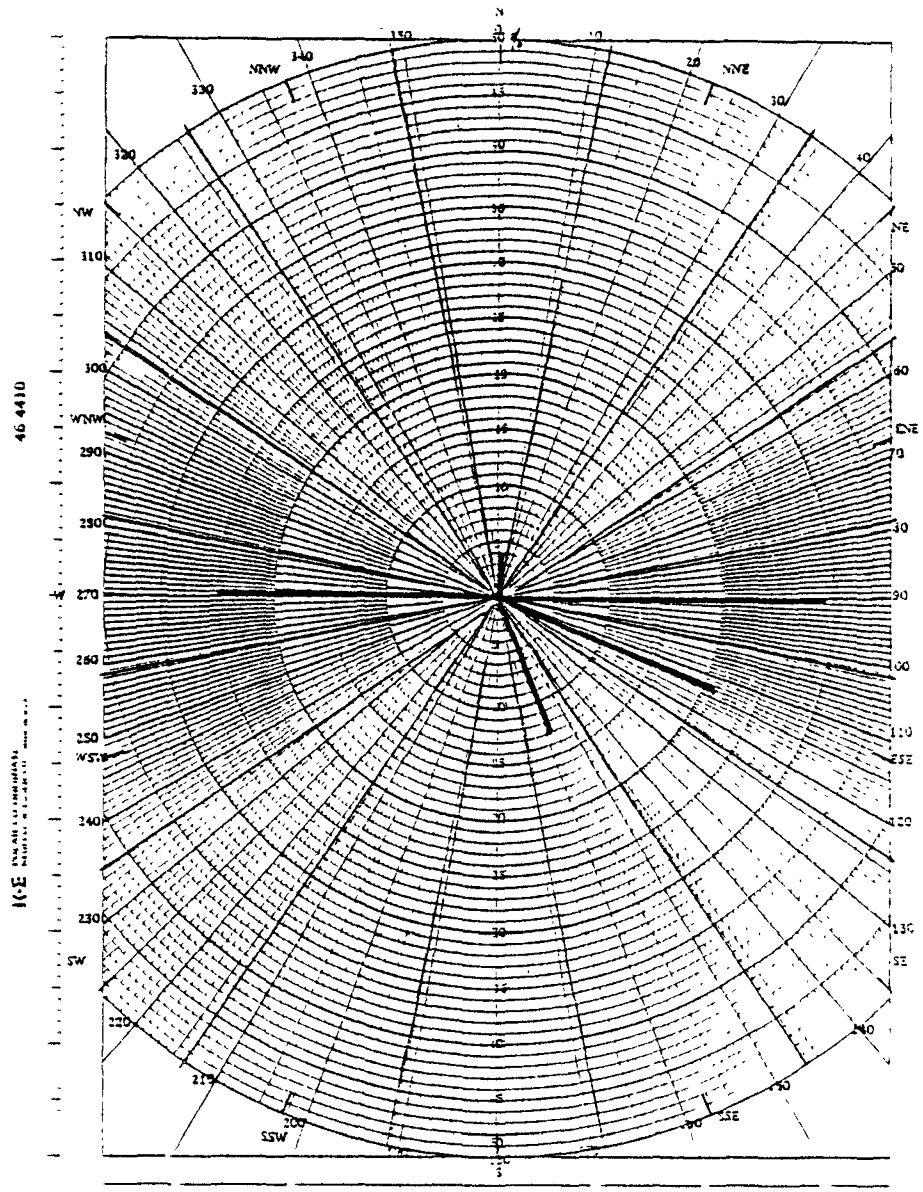

Figure G-7. Sun and Chesapeake, and BWI Airport Data, October 25, 1977 (8% calm)

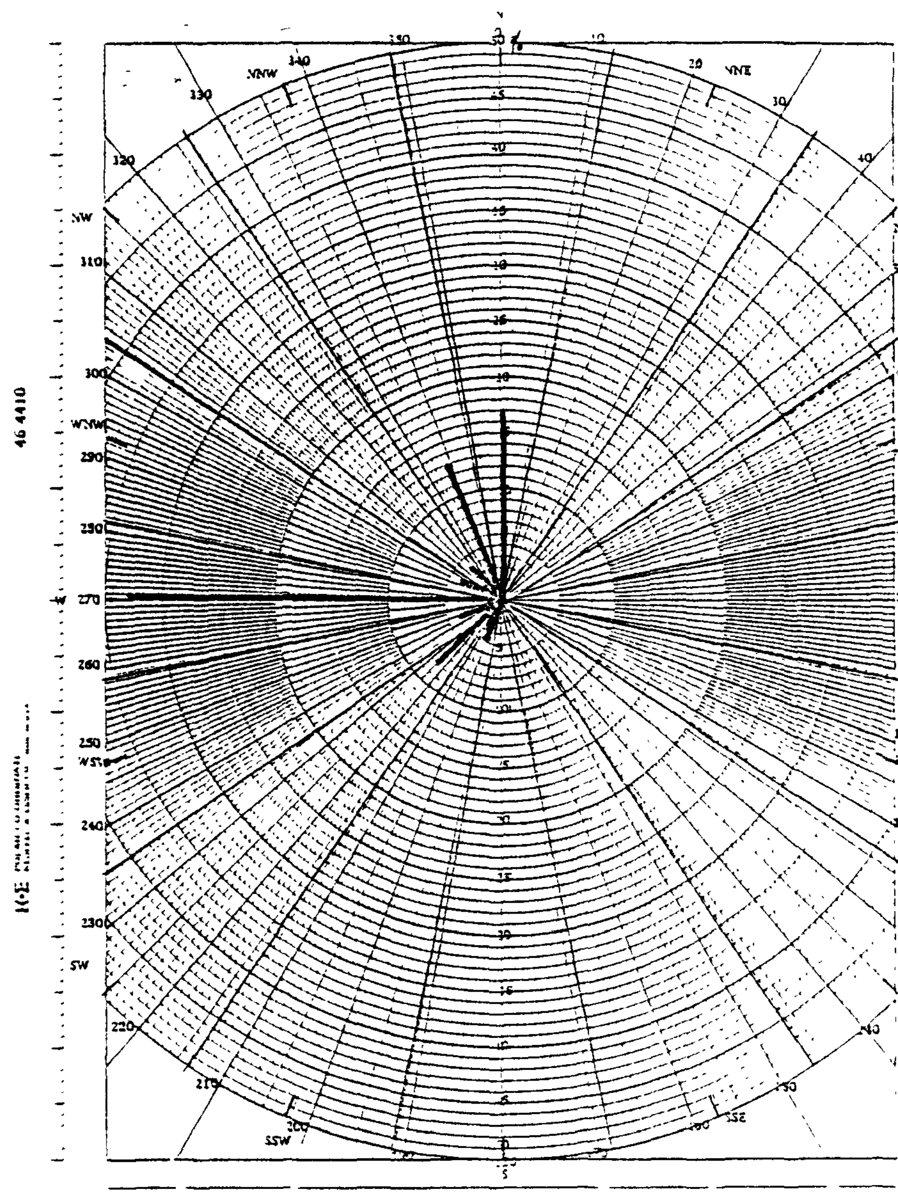

Figure G-8. BWI Airport Data, November 24, 1977 (13% calm)

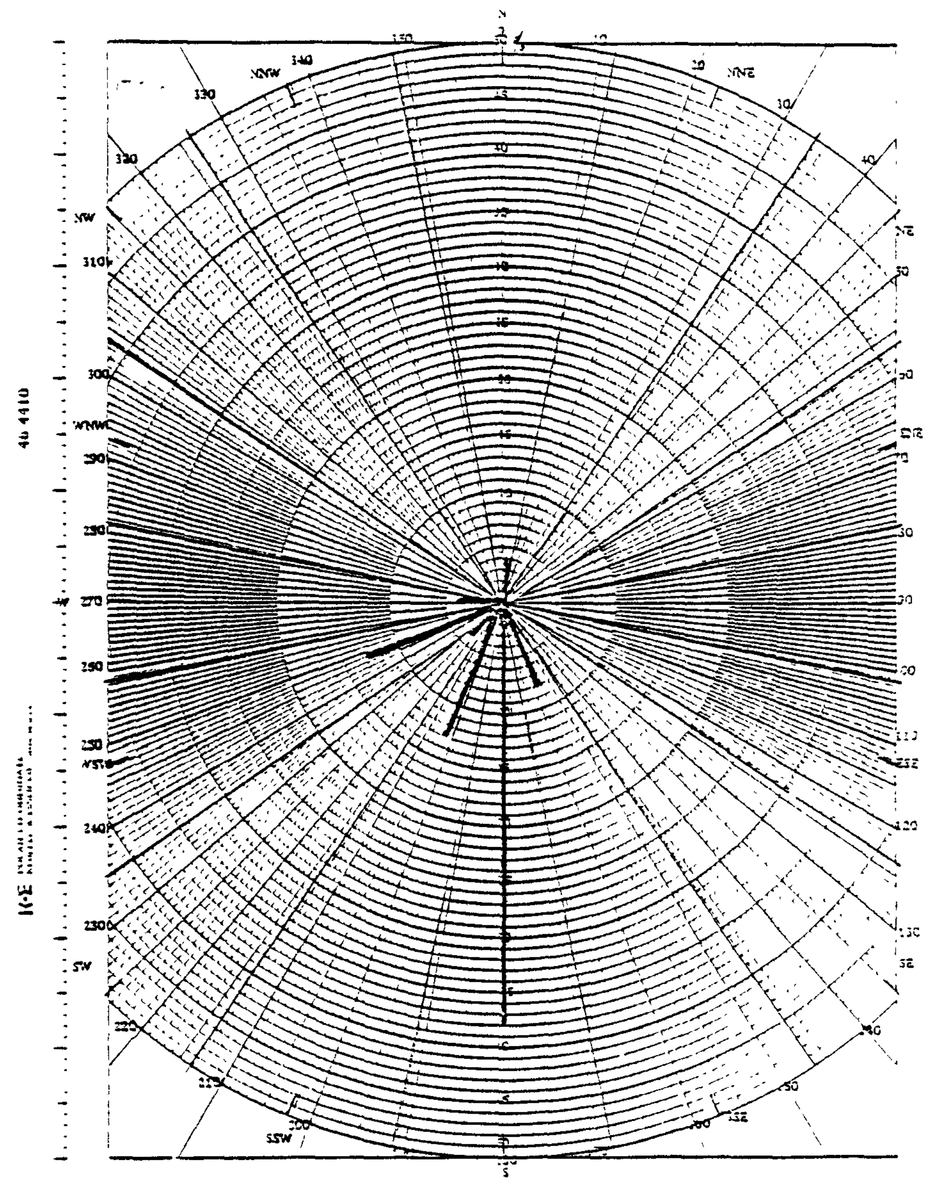

Figure G-9. Suni and Chesapeake, and BWI Airport Data, December 12, 1977 (17% calm)